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HARDWARE PERFORMANCE ANALYSIS OF THE BASIC NARROW
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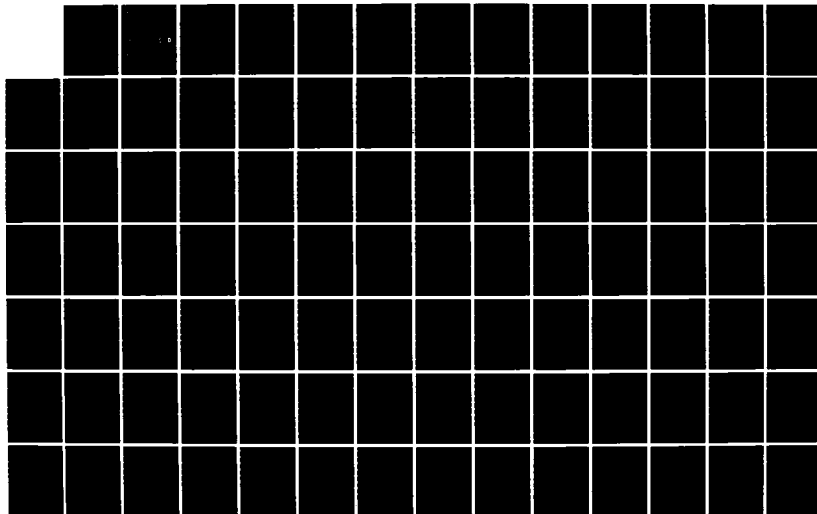
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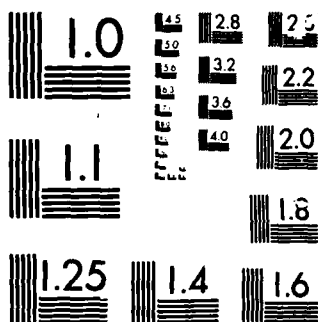
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Hardware Performance Analysis of the Basic Narrow Microwave Landing System (MLS) at Washington National Airport (DCA) in the Service Test and Evaluation Program (STEP)

Marvin S. Plotka

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September 1985

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16. Abstract This is the final technical note for the "Hardware Performance Analysis of the Basic Narrow Microwave Landing System (MLS) at Washington National Airport (DCA) in the Service Test and Evaluation Program (STEP)" for the period January 1, 1981 through June 30, 1983. The MLS configuration, limits of signal operation, system and subsystem operation, data collection and analysis are described. Equipment and environmental problem areas uncovered during the test and evaluation are discussed in the Results section of this report. Chargeable failures are identified and listed and engineering investigations are discussed. Remote Maintenance Monitoring System (RMMS) data analysis are presented. Conclusions and recommendations are listed.			
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EXECUTIVE SUMMARY

The Service Test and Evaluation Program (STEP) Microwave Landing System (MLS) located at Washington National Airport (DCA) was evaluated to develop hardware performance summaries which include reported failures, outages, out-of-tolerance conditions, and statements on trends, performance variation patterns, and failure modes correlated with environmental conditions. STEP is a joint effort by many elements of the Federal Aviation Administration (FAA) including APM, ACT, AAT, and AFO. The prototype Basic Narrow MLS was operationally evaluated at DCA during the STEP program.

Data collection forms and techniques of the STEP program were utilized. Additional information details which were entered only on the facility maintenance logs were requested from the site technical personnel. No additional instrumentation nor facilities were necessary in this analysis. The last 2.5 years of the 4.5 years of system operation and failures in the Basic Narrow STEP data were analyzed and reported with respect to mutually agreed upon criteria described in the project plan, report number DOT/FAA/CT-TN83/14, dated April 1984.

The azimuth subsystem experienced two chargeable failures causing executive faults and four chargeable failures not resulting in executive faults. There were six nonchargeable failures causing executive faults, five of which involved the radio frequency switch assembly and loose terminal board screw connection. There was one nonchargeable failure that did not cause an executive fault.

The elevation subsystem had no chargeable failures causing executive faults. There were four chargeable failures not causing executive faults, two of which were located in the maintenance monitor cathode ray tube power supply and the other two related to the air conditioning system. There were four nonchargeable failures causing executive fault, three of which related to airport construction and maintenance moving vehicles causing physical change to the subsystem. There was one nonchargeable failure not resulting in an executive fault.

Other causes of executive faults in both subsystems were power outages and the deteriorating hydrophobicity characteristic of the beam antenna radomes. The elevation subsystem lost azimuth synchronization signal from the azimuth subsystem resulting in the elevation subsystem going into the executive fault whenever the azimuth subsystem experienced equipment failures, azimuth site power losses, azimuth site engineering changes tests, and azimuth subsystem executive faults due to bad weather and radomes maintenance.

The plotted Remote Maintenance Monitoring System (RMMS) parameters were operating within specification the vast majority of the time. The causes of the out of tolerance conditions were identified in most of the events when log data were kept. Trends, curve variations, and variation patterns were identified from the yearly plots. Their relationship with the identified equipment failure, DCA airport temperature conditions throughout the year, and time of day were developed.

The highlights of the conclusions are as follows:

1. The MLS system had a good hardware performance during the 2.5 year analysis period with only two chargeable equipment failures causing system downtime and eight other chargeable equipment failures causing no system downtime.
2. There were no recurrent equipment failures in the MLS for the test period.
3. The need for air conditioner/heater assembly equipment may not be required for this MLS location.
4. The buried cable and waveguide for this MLS were vulnerable to physical abuse from airport construction and maintenance equipment and repairmen.
5. An uninterruptable power source system of 2 hours duration would have reduced the MLS power outage related downtime between 75 and 94 percent (uncertainty due to recording instrumentation inaccuracies).
6. The MLS operation was less sensitive to precipitation when the vertical aperture of the elevation monitor pole antenna was increased during an engineering test.
7. The MLS had a significant number of executive faults which did not automatically clear that required manual intervention to reset the system.
8. The plotted RMMS data year to year, season by season, and morning to night comparisons indicate DCA airport temperature and time of day had little impact on the MLS's operation. All four plotted parameters indicated within specification operation regardless of the airport temperature or time of day.
9. RMMS data can be used for indications of equipment failures (hard or soft) and adverse environmental effects.

If the following recommendations are implemented, this MLS should make a good candidate system for a low maintenance production system. The important points of the recommendations are as follows:

1. The MLS system's buried cable and waveguide should be examined for ways to decrease their vulnerability to physical abuse from airport construction and maintenance equipment and repairmen.
2. An uninterruptable power source (UPS) power system should be included at each subsystem site to increase MLS operational reliability and availability.
3. The MLS should be designed to eliminate its sensitivity to environmental temperature to preclude the use of air conditioner/heater assembly equipment.
4. The subsystem automatic restart feature associated with the executive monitor equipment should be examined to determine if the number of manual interventions could be decreased by extending the executive monitor restart cycle time.

INTRODUCTION

PURPOSE.

The Service Test and Evaluation Program (STEP) Microwave Landing System (MLS) located at Washington National Airport (DCA) was evaluated to develop hardware performance summaries which include reported failures, outages, out-of-tolerance conditions, and statements on trends, performance variation patterns, and failure modes correlated with environmental conditions.

BACKGROUND.

During August 1982, APM-410 personnel presented and discussed with ACT-140 personnel a work statement by APM-410 covering the reduction and analysis and the subsequent reporting of the data from the MLS STEP program effort. This program effort commenced during January 1979 with the installation of the basic narrow MLS at DCA, and will be terminated at the end of September 1985. During the subsequent months, and after a number of negotiations, APM-10 personnel submitted a request to ACT-1 (memo dated October 22, 1982) asking for Technical Center support. ACT-140 personnel responded by developing a Program Directive (Project No. 076-320-120) in April 1983. The Basic Narrow MLS was removed from the STEP program September 30, 1983, when it was relocated to the heliport at the Technical Center. This project is currently included in the Landing Systems Program, Number T06. The current Program Directive number for the project is T06-01D; the subprogram number is 076-320.

RELATED DOCUMENTATION/PROJECTS.

The Basic Narrow and Small Community MLS's used in the STEP program are being tested to the following specifications.

1. FAA-ER-700-01, Basic Engineering Requirement, amendment 2, changes 1 through 6.
2. FAA-ER-700-04, Small Community Engineering Requirements, amendment 1, changes 1 and 2.
3. FAA-ER-700-07, Functional Requirements, amendment 2, changes 1 and 2.
4. FAA-ER-700-08A, Signal Format Specification, amendment 2, changes 1 through 7.

The Bendix Basic Narrow MLS was delivered and installed at DCA by Bendix Communications Division, Baltimore, Maryland, under contract DOT/FA-72WA2801 awarded in 1972.

The following is a list of technical manuals and operations and maintenance instructions on the Basic Narrow MLS equipment:

1. Bendix Corporation, Communications Division, Antenna Subsystem, Basic Narrow Ground Equipment, Technical Manual and Operations and Maintenance Instructions, TI 6850.30, July 1978.
2. Bendix Corporation, Communications Division, Maintenance Monitor Display, Basic Narrow Ground Equipment, Technical Manual and Operations and Maintenance Instructions, TI 6850.31, July 1978.
3. Bendix Corporation, Communications Division, Ground Subsystem, Basic Narrow Ground Equipment, Technical Manual and Operations and Maintenance Instructions, TI 6850.32, Volumes 1 and 2, July 1978.
4. Bendix Corporation, Communications Division, Ground Electronics, Basic Narrow Ground Equipment, Technical Manual and Operations and Maintenance Instructions, TI 6850.33, Volumes 1 and 2, July 1978.

Other related MLS documentation concerning reliability and maintainability are as follows:

1. Plotka, M. S., Project Plan for the Hardware Analysis of Selected Microwave Landing System (MLS) in the Service Test and Evaluation Program (STEP), Technical Note No. DOT/FAA/CT-TN83/14, FAA Technical Center, Atlantic City Airport, New Jersey, April 1984.
2. Plotka, M. S., Reliability and Maintainability Evaluation of the Prototype Basic Wide Microwave Landing System at Wallops Island, Virginia, Technical Note No. DOT/FAA/CT-TN83/06, FAA Technical Center, Atlantic City Airport, New Jersey, December 1983.
3. Horton, G. J., A Data Collection System for Remote Microwave Landing Systems, Letter Report No. CT-82-100-104LR, FAA Technical Center, Atlantic City Airport, New Jersey, September 1982.
4. Moeller, A. W., and Willey, R. E., Investigation of Hydrophobic Radomes for Microwave Landing System, Final Report No. DOT/FAA/RD-82/87, Program Engineering and Maintenance Service, FAA Headquarters, Washington, D.C., November 1982.

A Department of Transportation, FAA Order, No. 6830.2, entitled "Maintenance of Microwave Landing System (MLS) Equipment During Service Test and Evaluation Program (STEP)," May 12, 1982, describes in detail the data collection forms, information, and procedures for the collected data used under the test plan.

DISCUSSION

EQUIPMENT CONFIGURATION.

A typical MLS consists of two subsystems: azimuth (AZ) and elevation (EL), with or without a precision distance measuring equipment (DME) collocated at the AZ

site. The typical Basic Narrow MLS site configuration is shown in figure 1. In this hardware performance analysis, the precision DME will not be evaluated due to their close similarity to commercially designed equipment.

The EL subsystem consists of a transmitting antenna, a monitoring antenna, and a shelter. The EL transmitting antenna is located approximately 1,000 feet back from threshold, and is offset from the runway centerline by about 250 feet. The EL monitoring antenna is located approximately 150 feet in front of the EL transmitting antenna; the EL shelter is located approximately 15 feet to the side of the EL transmitting antenna.

The AZ subsystem also consists of a transmitting antenna, a monitoring antenna, and a shelter. The AZ transmitting antenna is located approximately 700 feet beyond the runway stop end on the extended centerline. The AZ monitoring antenna location is approximately 100 feet in front of the antenna just off centerline. The AZ shelter is located to the side of the AZ transmitting antenna.

The precision DME system is collocated in the MLS Basic Narrow AZ shelter and its antenna is attached to the shelter. This system does not have a monitoring antenna.

The remote control equipment is typically located in the air traffic control (ATC) tower and controls the overall system. It contains visual system status indicators.

At the DCA Basic Narrow MLS, intersite communications are provided by the commercial telephone system.

SYSTEM OPERATION.

The MLS generates lateral and vertical angular guidance to aircraft within the volume of coverage. When a precision DME system is collocated with an MLS, it provides range information to the aircraft. STEP Order 6830.2 gives a more complete description of system operation. Details of the various systems' operation are given in the related technical manuals previously mentioned.

SUBSYSTEM OPERATION.

The Basic Narrow AZ subsystem consists of a phased-array approach antenna, an electronics shelter that has sector antennas (for forward identification, left and right side out-of-coverage indication (OCI)), and a precision DME transponder system (shown in figure 2). The AZ subsystem electronic timing and control circuits (which produce all the clock and control signals) cause all signals radiated from the AZ shelter to synchronize within the time division multiplexed (TDM) format. The radio frequency (RF) waveforms are generated by a C-band exciter and phase and amplitude modulators. A traveling-wave tube amplifier, with an integral power supply, provides a 20-watt output at the sites' operating frequency. The antenna select switch is controlled in time synchronization with the RF signal. The signal is routed to the correct antenna on the AZ shelter. The order of antenna selections is as follows:

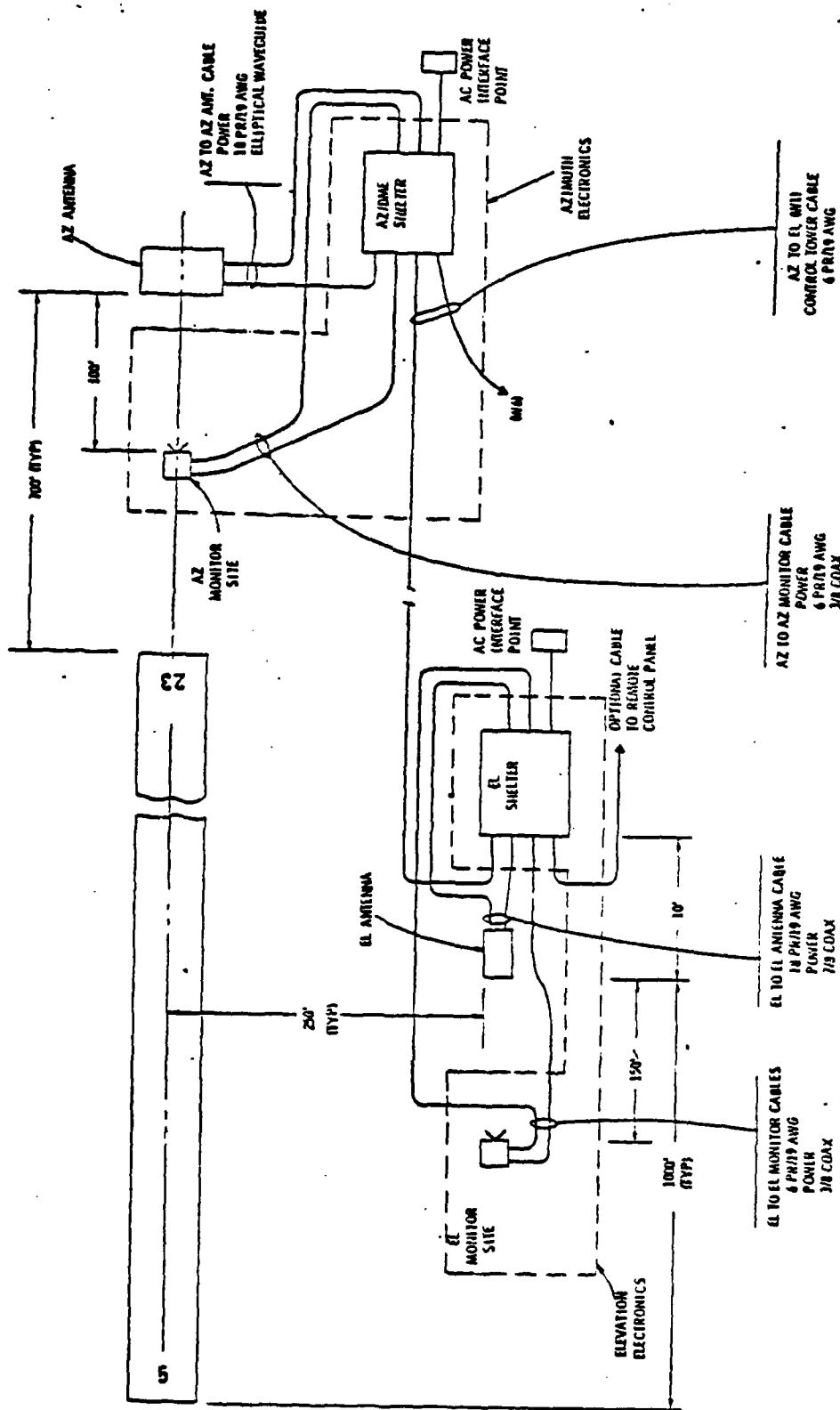


FIGURE 1. BASIC NARROW NLS CONFIGURATION

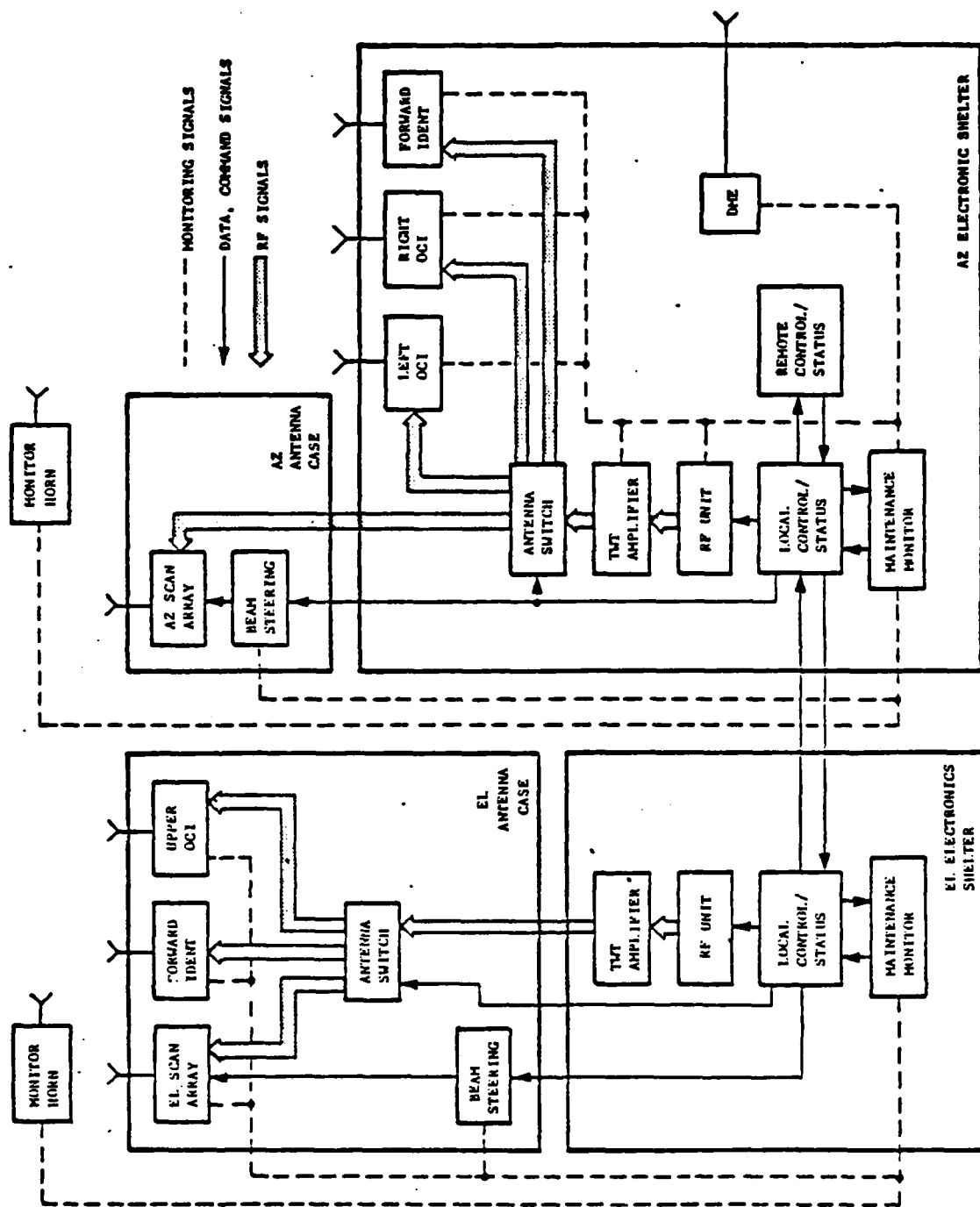


FIGURE 2. BASIC NARROW MLS BLOCK DIAGRAM (WITHOUT RMMS SHOWN)

(1) the forward ident antenna, (2) the scanning beam antenna which radiates the RF in the to-fro scan, and (3) the OCI antennas (right to left) which radiate the out-of-coverage indicator pulses.

The scanning beam antenna has an array of 64 slotted waveguide radiating elements that are fed by a strip-line power divider. The slotted waveguide radiating elements are controlled in a ROTMAN lens design. The elements are controlled by an ordering of digital control words in the scan interval which causes the phase gradient across the array to rotate about the array center. A narrow fan beam is produced that is steered $\pm 40^\circ$ through the AZ proportional guidance coverage sector. The ordering of control words for the ROTMAN lens antenna is produced in the beam steering unit. The linear scanning rate is $20,000^\circ$ per second.

Site radiated signal monitoring is built-in. Both executive (system has failed) and maintenance (system is functioning within its specified limits) states are monitored. The executive state monitoring checks the critical system parameters and initiates executive action of automatic subsystem shutdown when a parameter does not fall within a predetermined tolerance. Maintenance monitors sense component and line replaceable unit (LRU) performance as opposed to final system performance. Maintenance monitor thresholds are set close enough to nominal values so that subsystem degradation is normally detected before an executive fault occurs. Consequently, scheduled maintenance and corrective maintenance can be taken to minimize executive system shutdowns. If a maintenance monitor exceeds its limit by a large margin, executive action limits will be exceeded so that a subsystem shutdown and a maintenance alert occur.

The precision DME transponder in the AZ shelter is controlled and monitored by the proportional guidance electronics. This transponder transmits and receives at L-band frequencies through the precision DME antenna with a $\pm 70^\circ$ forward coverage.

The Basic Narrow EL subsystem is basically identical to the Basic Narrow AZ subsystem as to equipment grouping and functional operation (figure 2); however, only two sector antennas are required. The EL subsystem is slaved to the AZ subsystem for synchronization of the EL subsystem transmissions within the MLS TDM format.

Refer to table 1 for the subsystems' operational coverage limits.

TABLE 1. BASIC NARROW COVERAGE

Equipment Signals Limits of Operation

<u>Element</u>	<u>Maximum Altitude (Ft)</u>	<u>Horizontal Coverage</u>		<u>Vertical Coverage</u>	
		<u>Systems Limits</u>	<u>Proportional Limits</u>	<u>System Limits</u>	<u>Proportional Limits</u>
Azimuth	20,000	<u>+40°</u>	<u>+40°</u>	1° to 20°	
Elevation	20,000	<u>+40°</u>		1° to 15°	1° to 15°
Precision DME	20,000	<u>+70°</u>		1° to 15°	

Note: Maximum Range for all elements is 20 nautical miles (nmi)

Additional detailed specification requirements may be found in the related technical manual documents: Items 1 through 4 and in the STEP document, Order No. 6830.2

DATA COLLECTION.

A data base existed at the start of the evaluation on September 23, 1983 (the day after the data books covering the period January 1, 1981 to June 30, 1983, were received from APM-410 at the Federal Aviation Administration (FAA) Technical Center). The testing period began on April 1, 1979 (at the end of the Basic Narrow MLS installation period). Data continued to be collected at DCA on this MLS until September 30, 1983. The system was immediately disassembled and shipped to the FAA Technical Center during October 1983 for use on the project T07-01B, "Evaluation of MLS for Helicopters."

Data collection consisted of manually recorded maintenance, failure and outage events, or situations which were different from the normal energized and operational status of the equipments. Such events included: shutdown of any equipment unit, preventive maintenance (when shutdown of an equipment unit was involved), hardware failures, engineering changes, changes in system configuration, site power variations and outages, and site weather conditions. The primary means of recording data was the Facility Maintenance Log Form, FAA Form 6030-1. In addition, Technical Performance Records forms were utilized to manually record selected signals measurements which were compared to the signals' respective tolerance limits. This measurement set was accomplished twice a day, once in the morning and once in the afternoon, each workday by the site technician. Where available, Russtrak analog recorders continuously monitored selected primary signals. The signals were calibrated and the analog traces indicated the monitored signals' magnitudes. Dates and approximate

times were handwritten by the site technician on the analog chart paper.

Remote Maintenance Monitoring System (RMMS) data were remotely and semiautomatically collected and reduced by Technical Center personnel and equipment via commercial telephones and site related, specially installed modems at the DCA Basic Narrow MLS. All RMMS parameters were recorded at the Technical Center on magnetic computer tape. These data were collected twice a day, once in the morning and once in the afternoon, each workday. A few parameters were selected for data plotting on a monthly basis, showing both morning and afternoon data on the same plots. The DCA Basic Narrow parameters plotted for each subsystem were beam accuracy, beam effective radiated power (ERP), travelling-wave tube amplifier (TWTA) power output, and antenna temperature.

The STEP document, order No. 6830.2, presents parameter details and completed sample forms of all the data except the analog Russtrak recorder data. RMMS data listings are detailed and plots are shown in report No. CT-80-100-104LR. The Russtrak recorders used at DCA are ordinary two-channel analog recorders, which were usually recording beam accuracy and effective radiated power parameters.

Weather data are provided for DCA by the National Oceanic and Atmospheric Administration (NOAA) on a monthly basis. APM-410 received these data and sent them to ACT-140.

Failure and maintenance data, changes in operational status, and environmental information were entered on the Facility Maintenance Log Form and included a complete and comprehensive history of every hardware failure, regardless of whether or not such failure or other type occurrence resulted in a degradation of system performance. The failure history included the following:

1. Date and time of any hardware failure or other type occurrence.
2. Brief description of hardware failure or other type occurrence.
3. Symptoms of failure or other type occurrence.
4. Effect of failure or other occurrence on subsystem and system operation.
5. Location of failure or other occurrence (including subsystem, unit, drawer, and slot number).
6. Name of corrective maintenance diagnostics or procedures used.
7. Date and time hardware failure or other occurrence is corrected.
8. Name, location, and serial number of failed part(s).
9. Disposition of failed part (replaced, repaired, discarded, returned to manufacturer, etc.).

10. If failed part or item is repaired off-line, report the off-line repair time and give name and location of defective part or unit.

11. Other information: temperature, humidity, environmental items lightning, rain, etc.), low power, backup power used, loss of cooling, etc.

Refer to appendix C for sample presentations of the azimuth and elevation subsystems facility maintenance logs, Russtrak recordings, technical performance records, checklists, and monthly RMMS plots (beam accuracy parameter).

DATA REDUCTION AND ANALYSIS.

The data base was too large to be reduced, analyzed, and reported within the specified evaluation period with the resources available to the project.

Therefore, the data base was divided into three parts:

Part 1 - From April 1, 1979 to December 31, 1980

Part 2 - From January 1, 1981 to June 30, 1983

Part 3 - From July 1, 1983 to September 30, 1983

For at least the last half of part 3, the azimuth subsystem status was in beam accuracy parameter executive fault due to a tilt of the monitor pole caused by a structural shift of the pier on which it was installed. Also, part 3 data were not available to the evaluation personnel until November 1983. Part 2 data were considered the right size to be evaluated within the specified project time and resources. Part 2 data were more recent than part 1 data.

From the equipment logs, each reported failure was analyzed to determine whether it was a chargeable actual equipment failure. The reliability model scope was limited to the actual MLS equipment including the shelters, air conditioning equipment, and antenna enclosures. Power sources and external causes for executive faults such as construction equipment and field grass mowers were not considered chargeable. The criteria for equipment failure chargeability are as follows:

1. The failure is independent, that is, it did not occur as a result of a previous failure or hardware modification.
2. The failure causes a loss or degradation of performance beyond specified or acceptable limits of the equipment unit (reliability element) in which it occurred.
3. The failure requires actual maintenance effort to correct, as opposed to transient outage which can be manually reset.

Operational failures may be related to equipment, site power, or environment. These individual equipment or operational failure analyses included: coordination with site maintenance personnel to resolve questions of chargeability, type of maintenance effort expended, and any other questions concerning the failure that arose during the course of the analysis.

A listing of the failures occurring was made which includes a documentary on each failure, including its chargeability, dependent upon availability of relevant information. Presentation of these failures aided in determining if distinct or repetitive failure patterns existed. Refer to figure 3 for a matrix presentation of data analysis summary.

In this DCA system (which has Russtrak recorders), the beam accuracy and beam effective radiated power parameters were reviewed thoroughly to determine when and how well the guidance information was transmitted. This information was correlated with the failure and other site outage situations. When failures and other site outages occurred, the technical performance record, weekly and monthly maintenance records, RMMS data, and weather data were examined for correlation.

The RMMS data include 120-column computer printouts of all the automatically recorded parameters' amplitudes, limits, immediate past previous amplitude, etc. Also, the DCA Basic Narrow System beam accuracy, beam effective radiated power, TWTA power output, and antenna temperature parameters for both the AZ and EL subsystems were plotted by monthly intervals indicating each workday's morning and afternoon parameter amplitudes referenced to the parameter's limit(s). Plots of yearly quantities of data were developed for the analysis, parameter by parameter, from July 1 to the following June 30, or 12 months of data for each of the two RMMS years of data. Yearly plots were developed with only a.m. or p.m. collected data. Additional yearly plots were developed with both a.m. and p.m. data. The yearly plots were compared for morning to afternoon, seasonal and yearly trends, variation patterns, out of tolerance conditions, and failure modes. The plotted data were correlated with any reported environmental conditions. Weather data at the DCA airport were reported by NOAA.

RESULTS

EQUIPMENT FAILURES.

1. Azimuth Subsystem.

a. Four radio frequency switch one (RF SW-1) assemblies failed due to external reasons. Therefore, none of these failures were chargeable. They were caused either by intermittent power supply levels or the site's input alternating current (ac) power being removed. Refer to appendix A, Failures Listing, paragraph No. 1, for a detailed explanation on production and repaired RF SW-1 assemblies. These as well as the other equipment failures are summarized in table 2.

(1) The RF diode requires a forward bias power supply level to limit the RF energy (current) in it, but if that power supply level was intermittent such as at terminal board (TB) -2, then there were periods that the RF energy in the diode exceeded its specification. Consequently, the RF diode burned up and shorted out which, in turn, burned open the diode's driving resistor.

<u>MLS System</u>	<u>Objective</u>	<u>Data Collected</u>	<u>Method of Analysis/ Interpretation</u>	<u>Results</u>
DCA Basic Narrow	Hardware Performance Summaries, Trends, Variation Patterns, Repetitive Failure Modes, Climatological Correlations	Failures Outages, Out-of-Tolerance Conditions, Twice per Weekday Parameters Measurements, Continuous Selected Parameter Measurement, Climatological	Comparison Interpretation and Correlation of Data from Facility Maintenance Logs, Russtrak Recorders, Technical Performance Records, RMS Reports Climatological Reports	Reported Failures List, Outages List, Out-of-Tolerance Conditions List, Identification of Trends, Variations Patterns, Failure Modes, Correlations with Climatological Conditions

FIGURE 3. DATA ANALYSIS SUMMARY MATRIX

TABLE 2. AZIMUTH SUBSYSTEM SUMMARY SHOWING CHARGEABILITY
TO THE ACTUAL MLS EQUIPMENT

Azimuth Subsystem Paragraph Designation	Item	Batch Prod. Rep'd				Number of Units of Azimuth Subsystem	Number of Failed Units in Azimuth Subsystem	Number of Failures From Batch				Failures			Related Information
		1	2	3	4			1	2	3	4	Number of Chargeable LRU	Causing Executive Fault		
													Yes	No	
1.	RF SW-1 Assy.	6	6	4	2	1	4	2	2	0	0	0	X		Intermittent power supply or loss of a.c. power can cause assay. failures.
1a.	Screw Terminal Rack AI-TB2					23 each TB-1;2.	1				0	0	X		Tightened loosened screw terminal; probably due to modification after sub-system installed.
2.	Scan Modulator Assy.					1	1				1	1	X		Thermocouple sensor detection circuit failed.
3.	Beam Antenna Radome and its Deicing Circuit					1	1				1	1		X	Radome fire caused by possible manufacturing defect in the deicing unit
4.	15 Volt power Supply Assy.					1	1				1	1	X		Two bad output capacitors.
5.	Light Emitting Diode					18	1				1	1		X	Dialy Lit.
6.	RF Connector RF Unit Drawer					2	1				0	0	X		Tightened loosened RF connector; probably due to testing and investigatory work.
7	Beam Antenna Enclosure Air Conditioner					1	1				1	1		X	Compressor bad.
7	Shelter Air Conditioner Thermostat Terminal					1	1				0	0		X	Loosened wire connection (from thermostat) at air conditioner was tightened
7	Shelter Air Conditioner Seal					1	1				1	1		X	Leaking air conditioner shelter seal filled with RTV sealant.

(2) When the site's ac power is removed, it is thought that the TWT's hysteresis maintains the RF power (current) to the RF SW-1 assembly for a long enough duration to burn out the RF diode and its driving resistor. With the site power eliminated, the bias power supply level on the RF diode is not present resulting in diode failure (see a(1) above).

(3) There was no correlation between an assembly's port failure and the subsystem's power failing or removal of forward bias power supply level. The J-port that failed depended on which antenna was being fed RF energy at the time of the site ac power or forward bias level removal and the end of the TWT's hysteresis RF power feeding through the RF SW-1 assembly.

b. One scan modulator assembly failed because the thermocouple sensor-detection circuit was not properly operating. This failure was chargeable.

c. The beam antenna radome failed once when its deicing heater circuit copper busstape layers separated and arced with the nichrome heating wire setting the honeycomb's epoxy resin on fire. The contractor believes this was a manufacturing defect. This is a chargeable failure.

d. The two 15 volt power supply output capacitors failed with a "high" ripple on the output power. Both failures occurred at the same time, therefore, there was only one chargeable LRU failure.

e. One maintenance monitor drawer light emitting diode (LED) "soft" failed by becoming dim on lighting. Its failure was considered chargeable.

f. The J-4 cable connector to the RF unit drawer was found loosened. Tightening the connection to its plug solved the preamble executive fault occurrences. This failure was not considered chargeable.

g. There were several failures relating to two non-MIL Spec air conditioners in the azimuth subsystem. The beam antenna enclosure air conditioner had a failed compressor which was a chargeable failure. The shelter unit enclosure seal developed water leaks which were then sealed with RTV sealant (a chargeable failure). The shelter's thermostat was found to have a loose wire, which was tightened solving the problem (a nonchargeable failure).

(1) The failure of the air conditioner (bad compressor) in the beam antenna enclosure during the hot months of July and August 1981, allowed the enclosure temperature to rise from a nominal midafternoon operating temperature of 86° F (30° C) to a within specification maximum at midafternoon of 118.4° F (48° C). Without any beam antenna enclosure cooling, the subsystem remained in transmitting operation with the outside temperature never rising above 98° F (37.7° C) during the 1.25-month failure period. The lack of controlled operating environment for the beam antenna enclosure equipment did not hinder the proper operation of the signal transmission nor cause any other parameter to go into executive fault or maintenance alert at a maximum outside temperature of 98° F (37.7° C) over the 1.25 month summer (1981) failure period. The beam accuracy and beam ERP parameters during that failure period were unaffected by a maximum enclosure operating temperature of 118.4° F (48° C), which was close to the beam antenna enclosure's specification limit of 122° F (50° C).

(2) Similarly, there were two failures of the subsystem shelter's airconditioning system in June 1981, when the outside temperature was 98° F (37.7° C). Also, the shelter's electronics temperature parameter (during the failures) experienced a more reduced range of temperature change than mentioned in paragraph g(1) for the same maximum specification limit of 122° F (50° C). Similarly, the shelter's inside temperature had no significant effect on the operation of the electronics equipment, the subsystems transmission operation, and the magnitudes of the beam accuracy and beam ERP parameters (as observed on the analog tracings).

As shown in table 2, three of the thirteen failed units related to the air conditioning systems. Two of those failures were considered chargeable and none of the three caused executive faults. The beam radome deicing circuit and maintenance monitor drawer LED chargeable failures also did not cause executive faults.

Four RF SW-1 assemblies failed in the azimuth subsystem due to an intermittent power supply level to them. This intermittency was caused by a screw connection loosening on the power supply's TB-2 with the continuing vibration of a fan (added by modification to reduce hot spots) next to it. The RF SW-1 assembly failures were not considered chargeable since they were not the primary cause of the failures, but the failures did cause executive faults. The TB-2 loose connection also caused executive faults and was the primary cause of the RF SW-1 assemblies failures. Likewise, it was considered nonchargeable since it only needed retightening, but not replacement.

Of the thirteen failures, seven were not chargeable. Only two of the six chargeable failures caused executive faults. Six of the seven nonchargeable failures caused executive faults.

2. Elevation Subsystem.

a. Data line noise appeared on the synchronization (sync) signal between the AZ and the EL subsystem sites. Crosstalk from another data line (in the same cable) for a new airport facility was seen in the AZ sync signal. The sync signal was switched to another cable pair resulting in a satisfactory sync signal. This failure was considered nonchargeable to the MLS subsystem. It and other equipment failures are summarized in table 3.

b. The maintenance monitor cathode ray tube (CRT) display power supply failed two different times. Both failures were manifested by a vertically rolling CRT display. The first failure was a heat sensitive transistor U-14. The second failure was output capacitor C-44 which caused a 2 volt peak-to-peak ripple on the power supply output. Both components were replaced and the failures were considered chargeable.

c. The shelter's non-MIL Spec air conditioner had two components fail currently, but only one chargeable failure was counted since there was only one failure occurrence. The fan motor assembly failed. Following its repair the compressor was determined to be at fault and was repaired. While the air conditioner was undergoing repairs during the subsequent summer (1982), the shelter's exhaust fan operated continuously maintaining the inside temperature

TABLE 3. ELEVATION SUBSYSTEM FAILURES SUMMARY SHOWING CHARGEABILITY TO THE ACTUAL MLS EQUIPMENT

Elevation Subsystem Paragraph Designation	Item	Number of Units in Elevation Subsystem or Assy. or Board	Number of Failed Units or Assy. or Board in Elevation Subsystem	Failures			Related Information
				Number of Chargeable LRU	Causing Executive Fault	Yes No	
1.	Data Link Field Line	1	1	0	X		AZ sync signal line picked up crosstalk from newly tied-in Runway Visual Range System to airport cable (100 Pair).
2.	Maintenance Monitor CRT Display Power Supply	1	2	2		X	The power supply had two separate, distinct components fail: capacitor C-44 (3/17/83) and transistor U-14 (2/9/81).
3.	Shelter Air Conditioner Fan Motor and Compressor	1	1	1		X	The fan motor stopped rotating and later it was replaced. At that time, the compressor was found to not start. A new compressor was eventually obtained and installed. One LRU chargeable failure is determined due to both component failures occurring at the same time.
3.	Shelter Air Conditioner Seal	1	1	1			Leaking air conditioner shelter seal filled with RTV sealant.
4.	Site, Trenched ac Power Cable	1	1	0	X		Trenched power cable severed by a construction trencher going in wrong direction. It was spliced back together.
5.	Waveguide from Shelter to Beam Antenna	1	1	0	X		Trenched waveguide damaged by ac power cable repairing. Eventually, a new waveguide was installed following an effort to restore the original waveguide.
6.	Waveguide Connector to Hardline	1	1	0	X		A mower operator's inattention to field facility while cutting the field grass caused the mower to hit and damaged the connector between the waveguide and hardline. The connector was immediately replaced from site spare parts.
7.	RF Connector, RF Unit Drawer	2	1	0		X	Tightened loosened RF connector probably due to testing and investigatory work.

within specification limits. The peak outside temperature was 93° F (33.9° C) and the peak monthly average outside temperature was 85° F (29.4° C). Another chargeable failure relating to the shelter air conditioner/heater assembly was in the shelter-connection seal which was repaired by applying RTV sealant to the seal's contact surfaces. This should have been done during the air conditioner installation to prevent water leaks.

d. The trenched ac power cable to the site was severed by a construction trencher going the wrong way. The cable was spliced together. It was considered a nonchargeable failure to the MLS subsystem.

e. The trenched waveguide buried near the site ac power cable was damaged during the ac power cable repair. Efforts to repair the damaged waveguide were initially not successful due to gas leakage from the waveguide. Continuing efforts to repair the damaged waveguide were only partially successful and a new waveguide was installed. This failure was considered non-chargeable to the MLS subsystem.

f. A waveguide connector attaching a rigid coaxial cable to the waveguide was damaged by a field grass mower that got too close to this facility. This failure was considered nonchargeable to the MLS subsystem.

g. The RF connector on the input cable to the RF unit drawer had worked itself loose (probably due to the investigatory and test work performed by the contractor). This failure was considered nonchargeable.

Two of the four LRU chargeable failures shown in table 3 relate to the air conditioner systems, but they did not cause executive faults. Another two LRU chargeable failures, both relating to the maintenance monitor CRT display power supply, did not cause executive faults.

Three of the nonchargeable failures were caused by carelessness of airport personnel during the performance of their jobs mowing the field grass, trenching new cable lines, and repairing severed trenched cable. Each of these failures resulted in executive faults. The azimuth sync communication cable crosstalk problem was introduced during installation of a new airport facility. The crosstalk was satisfactorily reduced by removing the azimuth sync signal to another wire-pair in that cable. While the crosstalk was present, the elevation subsystem was in executive fault. The remaining nonchargeable failure was a loose RF connector at the RF unit drawer, which merely needed retightening. It allowed some RF leakage, but it did not cause an executive fault. Of the four LRU chargeable failures, none caused executive faults.

OUTAGES DUE TO THE ENVIRONMENT.

1. Azimuth Subsystem.

a. Power Outages.

(1) The MLS azimuth subsystem's ac site power was not connected to the airport's emergency power system. Consequently, any loss of commercial power, or the airport operating on emergency power system for testing, resulted in a loss of site power. There were some losses of commercial power to the airport.

However, in good weather there were many checks of the airport power system by airport personnel testing the emergency power system. The airport power system tests were not periodic throughout the year. These tests left the MLS without power for the test duration.

(2) The first MLS production purchase specification for the uninterrupted power source (UPS) system is 2 hours which covers approximately 75 percent of the experienced DCA operational power system outages during the test period as shown in appendix A, tables A-1 and A-2. An additional hour of UPS availability would raise the UPS coverage time to approximately 94 percent of the experienced failures. It should be noted that the method of measuring time on the analog recording and the nonlinear paper travel of the analog recorder resulted in the power outage measurements to be uncertain in magnitude by about 1 hour. Consequently, the percentage of total UPS time coverage under the UPS first MLS production specification may have included up to approximately 94 percent of these experienced power outages.

(3) The data collection period, part 2, covered 2.5 years from January 1, 1981, through June 30, 1983. The logs do not indicate why the two excessively long power outages occurred or endured. One happened in August 1981 and the other in December 1982. The power outages of August 1, 1981, November 24, 1981, and December 20, 1982, required manual restarting. The first two occurred during the week, one during the day and the other at night, while the third occurred during the weekend. In all cases, the site ac power was restored, but the subsystem failed to automatically restart. Thus, it remained in executive fault status until the site person manually restarted it when he arrived on site.

(4) Ten of the 32 power outages or 31.2 percent of them occurred on the weekends and only one (December 20, 1982) required a manual restart. The other 22 or 68.8 percent occurred on weekdays. Nine (28.1 percent) of the 22 occurred during the site person's normal workday and the subsystem automatically restarted in each case. The other 13 outages (40.6 percent) occurred during the site person's off-duty weekday hours and, in each case, the subsystem automatically restarted.

b. Weather Outages.

(1) On February 6, 1983, the snowfall started about 0800 hours and accumulated to 4.4 inches by 2400 hours that day. At 0700 hours on February 7 there was a 4.0-inch accumulation. The azimuth subsystem beam accuracy parameter went into continuing executive fault about 2300 hours on February 6. The system went into an executive fault status about 15 minutes earlier, but restarted automatically. The beam ERP parameter was down by 1 decibel (dB) at 2300 hours. The azimuth subsystem was manually restarted at 0735 hours on February 7 by the site person. The snow started melting as the air temperature warmed during the morning of February 7, from 32° F (0° C) at 0700 hours to 35° F (1.67° C) at 1000 hours. The beam accuracy parameter deviation increased by +0.04° deflection from 0700 to 0830 hours. Throughout the next hour, the temperature warmed further. The beam accuracy parameter then returned to normal. The beam ERP parameter during the snow's melting period was down by only 0.5 dB (maximum).

(2) On February 11, 1983, as the snow accumulation was building up to 16.4 inches, the beam accuracy parameter's executive faults occurred (on/off) frequently over the first half-day's period (about 20 executive faults). The subsystem stayed in beam accuracy parameter executive fault through the balance of that Friday and for the entire weekend, until the subsystem was manually restarted by the site person who enabled the reset switch the following Monday. The recorded analog tracking of the beam accuracy parameter showed no gradual increase in magnitude during the snowfall. These executive faults were direct, full one-way (+0.1°) deflections of the beam accuracy parameter. This parameter's executive fault limits at that time were +0.072°. The continuous executive fault started about noon on February 12, which may be indicative of the laying snow developing a slicker surface due to some melting in the day temperature of 35° F (+1.67° C) and then freezing in the night temperature of 29° F (-1.67° C). These data were obtained from DCA "Local Climatological Data," monthly summary for February 1983.

(3) As little as 4 inches of snow accumulation produced executive faults as described in paragraphs (1) and (2) above.

2. Elevation Subsystem.

a. Power Outages.

(1) Power outages described under Azimuth Subsystem Power Outages, paragraph 1a(1) and appendix B, table B-1, also apply to the elevation subsystem.

(2) The EL subsystem power outages' durations were similar to those of the AZ subsystem. The method of determining the EL subsystem power outages was the same as for the AZ subsystem and similar results could be expected.

(3) The AZ subsystem synchronization and "Transmission-on" (TRO) signals complicated the restarting of the EL subsystem following a power outage involving both subsystems. The synchronization signal from the AZ subsystem would be transmitted to the EL subsystem as soon as the sync signal stabilized in the AZ subsystem in the AZ subsystem's restarting process (following the common power loss). This would allow the EL subsystem to get in sync with the AZ subsystem as soon as possible before the EL subsystem comes out of executive fault. The EL subsystem will not come out of executive fault unless the TRO signal is received from the AZ subsystem (when the AZ subsystem is transmitting). If the restart time of the EL subsystem is more than 5 minutes, the EL subsystem will remain in executive fault until it is manually restarted by the site person.

b. Weather Outages.

(1) The EL subsystem beam antenna radome as well as its other radomes were never covered with teflon film as were the AZ subsystem's beam and monitor pole antennas radomes (on October 12, 1981). Prior to that date, both AZ and EL subsystems experienced executive faults due to precipitation. Following that date the AZ subsystem was relatively executive fault-free due to precipitation. However, the EL subsystem had an increasing number of executive faults related to adverse weather conditions. Some of those executive faults occurred with as little rainfall as 0.02 inches in the previous hour (refer to table B-2, August 11 and December 12, 1982).

(2) The hydrophobic teflon layer made a permanent difference on the AZ subsystem radomes with decreased susceptibility to precipitation. The brushed or sprayed on outer coats of primer and silibonds or Vellox that were tried on either AZ or EL subsystems deteriorated in time from weathering effects. The EL subsystem was much more susceptible to precipitation as the primer and Vellox topcoat applications deteriorated.

(3) For February 6-7, 1983, refer to the Azimuth Subsystem Weather Outages' first item (paragraph b(1)). The EL subsystem's beam accuracy parameter deflected $+0.02^\circ$ with unmelted snow on the ground. As the air temperature increased in the morning above 32° F (0° C), the ground surface permittivity (dielectric constant) increased with the increasing water content in the snow. This resulted in the reflection of the side lobes off the ground interfering with the direct signal at the field monitor. The beam accuracy parameter deflection increased positively until it reached $+0.072^\circ$ when executive fault status occurred. The executive faults that occurred were momentary, with each one having an automatic restart of the EL subsystem. The beam ERP parameter during this period varied between -0.5 and -1 dB .

(4) For February 11, 1983, refer to the Azimuth Subsystem Weather Outages' paragraph b(2) for an explanation of the snow effect on the recorded executive fault parameters. The EL beam accuracy parameter executive fault status followed that of the AZ subsystem due to the EL subsystems status dependence on the AZ sync signal status. However, the EL subsystem beam accuracy parameter deflection was only $+0.04^\circ$ (well below the fault limit) between executive faults.

c. Vehicular Interference.

(1) Field grass mowers and a weed killer spray truck caused most of the noncatastrophic interference to the facility's guidance signal executive fault status (see appendix B, table B-3). The interfering vehicles passed between the beam antenna and its monitor pole antenna briefly blocking the monitored guidance signal. All but one of the interfering occurrences were caused by a field grass mower.

(2) The interferences occurred from May through September, inclusively, in each test period year. All occurrences happened on weekdays. About 60 percent of the occurrences happened during the morning (0800 to 1200) and the balance occurred from 1200 to 1630 hours. All individual interferences were less than 1 minute in duration and allowed the subsystem to automatically restart.

(3) There was one catastrophic incident caused by an interfering field grass mower on May 22, 1981. It is explained in the Results Section, Equipment Failures, item 2a and in Appendix B, Failures Listing, item 6.

(4) The other catastrophic incident was caused by a construction trencher on January 5, 1982. It is explained in appendix B, Elevation Subsystem Failures History, item 4, and in the Results Section, Equipment Failures, item 2d.

d. Unknown Origins for Subsystem Outages.

(1) The three listed events for January 1983 shown in table B-4 are similar in executive fault duration and frequency. Also, the beam accuracy and beam ERP traces (on the Russtrak recordings) are similar in peak deviations for all three dates. Two of the three events occurred at similar times of the day. Weather was not a common factor. The Russtrak recorder tracings are dissimilar from the EL subsystem power outage recordings in that the events only affected the beam accuracy parameter. There was no apparent relationship to the AZ subsystem's operation, since that facility experienced no executive faults or other anomalies at those dates and times.

(2) The remaining two executive faults from table B-4 are unrelated to anything else in the data sets. One occurred on a weekend and the other at night. Nothing was known of the nature of these executive faults.

ENGINEERING INVESTIGATIONS AND CHANGES.

1. Azimuth Subsystem.

a. Under Related Documents concerning Reliability and Maintainability, item 4, appendix A, defines hydrophobicity as the characteristics of a surface coating to naturally have a dry and ice free surface. During the test period different types of surface coatings were tested on the antenna radomes to varying degrees of success. For recommendations on this subject, see item 4, section 4.5 (page 39).

b. The beam accuracy parameter executive fault limits were reduced from $\pm 0.13^\circ$ to $\pm 0.072^\circ$ on September 3, 1981, to conform to International Civil Aviation Organization (ICAO) MLS requirements. On June 17, 1982, the RMMS CRT display of the beam accuracy parameter's new executive fault limits were changed by prom modification. Neither of these changes altered the executive fault RMMS information transfer over the modem lines. The original limits prevailed in the remote automatic data callup. The subsystem availability was not affected by this change.

c. The original obstruction warning bulbs were thought to be manufactured by Westinghouse. Replacement bulbs were supplied by the FAA which were made by Norelco and lasted much longer. The Norelco bulbs are used in street traffic lights, but a serious problem exists from storage which is a physical separation between the bulb and its base. The physically good Norelco bulb from storage, typically, lasted longer than the original Westinghouse bulbs. Refer to table A-3 for usage of these warning bulbs in this subsystem.

2. Elevation Subsystem.

a. The ground or covering layer between the beam antenna and its monitor pole antenna have a reflecting spectral "point" between 37 and 53 feet from the beam antenna. The dielectric constant varies according to whether there is dry ground, snow, water, or ice as a reflecting surface in the spectral "point." A watery surface offers the highest dielectric constant and, consequently, the highest reflectivity.

A blade antenna for the monitor pole consisting of printed circuits and eight dipole elements was designed and developed by the contractor in response to an FAA request. It controls a voltage null over the spectral "point" by having a narrower beam width and the aiming of the antenna on the monitor pole. The effect of the reflectivity characteristic of the spectral "point" is significantly reduced, thereby, not viewing the additive multipath signal at the monitor pole antenna. The contractor's on-site test successfully demonstrated this blade antenna on February 7, 1983.

b. The FAA requested the contractor to provide RMMS go no-go status information of the Small Community MLS AZ and EL subsystems located elsewhere at DCA in the Basic Narrow MLS's RMMS dial-up information set. The contractor designed and successfully implemented this modification.

c. The AZ subsystem's synchronization signal may be transmitted via cable or air communication to the EL subsystem. The cable line was used in this evaluation period. The air installation is a much less costly and less time consuming to install. However, under test, the air sync was susceptible to aircraft and large vehicles physically blocking the signal in line-of-sight situations which frequently occurred at this airport.

d. For obstruction warning bulbs, refer to the discussion in Results, Engineering Investigations and Changes, Azimuth Subsystem, item 1c of this report and appendix B, table B-5, which is also applicable to the EL subsystem.

AZIMUTH SUBSYSTEM SYNCHRONIZATION SIGNAL.

1. Elevation Subsystem.

a. The history of AZ subsystem sync signal loss to the EL subsystem is given in appendix B, table B-6. As shown in this table, there are 44 incidents on sync signal loss. Thirteen of the 44 incidents (29.5 percent) saw the subsystem automatically restart. The balance (70.5 percent) of the subsystem restarts were by the manual intervention of the site person during regular duty hours. Thirty-six incidents (81.8 percent) occurred during the week, with the balance (18.2 percent) occurring on the weekend. On the weekend, two incidents started in the morning (0800-1200), two in the afternoon (1200-1630), one in the evening (1630-2400), and three at night (0000-0800). The one weekend evening incident was the only one which had an automatic subsystem restart.

During the week, 8 incidents (22.2 percent) started in the morning, 12 incidents (33.3 percent) in the afternoon, 5 incidents (13.9 percent) in the

evening, and 11 incidents (30.6 percent) in the night. In 12 (33.3 percent) of the 36 weekday incidents, the EL subsystem automatically restarted. The weekday incidents balance (66.7 percent) required manual intervention to restart the EL subsystem. The AZ subsystem sync signal resulted from AZ subsystem equipment failures, azimuth site power losses, AZ site engineering changes tests, AZ subsystem executive faults due to bad weather, radomes maintenance, and engineering changes.

REMOTE MAINTENANCE MONITORING SYSTEM DATA.

1. Azimuth Subsystem

a. The RMMS plots were visually examined and analyzed for trends, variations and variation patterns by comparing the plots year-to-year, season-to-season, a.m.-to-a.m., a.m.-to-p.m., and p.m.-to-p.m throughout the 2 RMMS data years. Out-of-tolerance conditions were visually identified by those data exceeding the respective parameter's plotted specification limit. Any exact values presented in the out-of-tolerance table were read from the corresponding computer printout listing for the plotted data plots. The plotted data include the following azimuth subsystem parameters:

- Beam Accuracy
- Beam ERP
- TWTA Power Out
- Antenna Temperature

The RMMS data analysis was visually accomplished due to a lack of human resources to apply computerized regression analysis for this project.

b. The corresponding composite a.m. and p.m. plots are shown in figures 4 through 11, while the related individual a.m. and p.m. plots are shown in appendix D, figures D-1 through D-16. The analyses of the plots are referenced in table 4 to the text notes listed below (under paragraph 3). The out-of-tolerance conditions for the azimuth subsystem plots are listed in table 5.

c. The following RMMS data plot analyses are presented by their reference note numbers from table 4:

DATA RECORDED AND PROCESSD BY THE FOR TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N.J. 08400

WASH. M.S. AZ. MONITOR: JUL. 1981-JUN. 1982

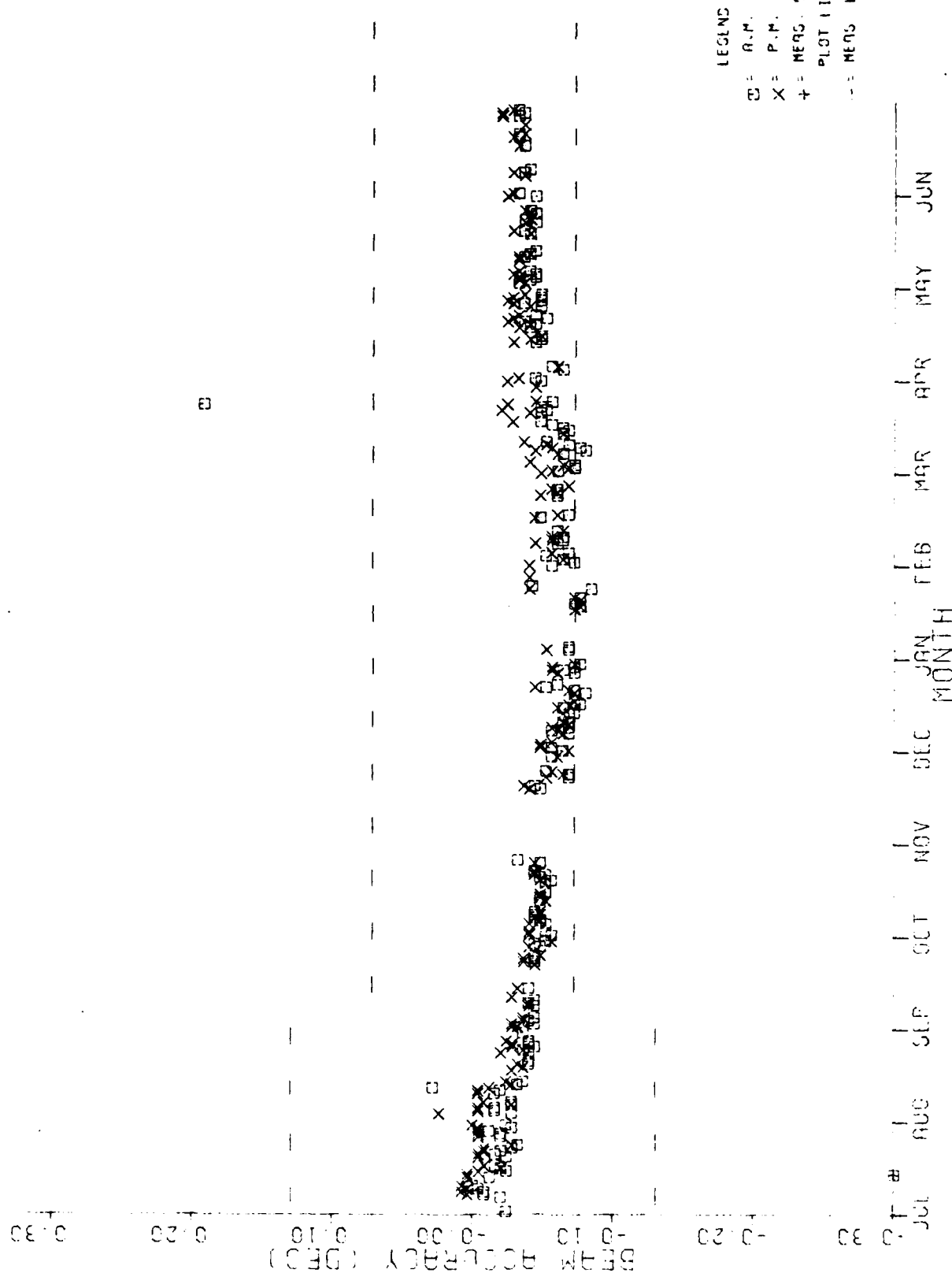


FIGURE 4. AZIMUTH MONITOR, JULY 1981-JUNE 1982, BEAM ACCURACY

DATA RECORDED AND PROCESSED BY THE F-99 TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

WASH. FLS AZ. MONITOR: JUL., 1981-JUN., 1982.

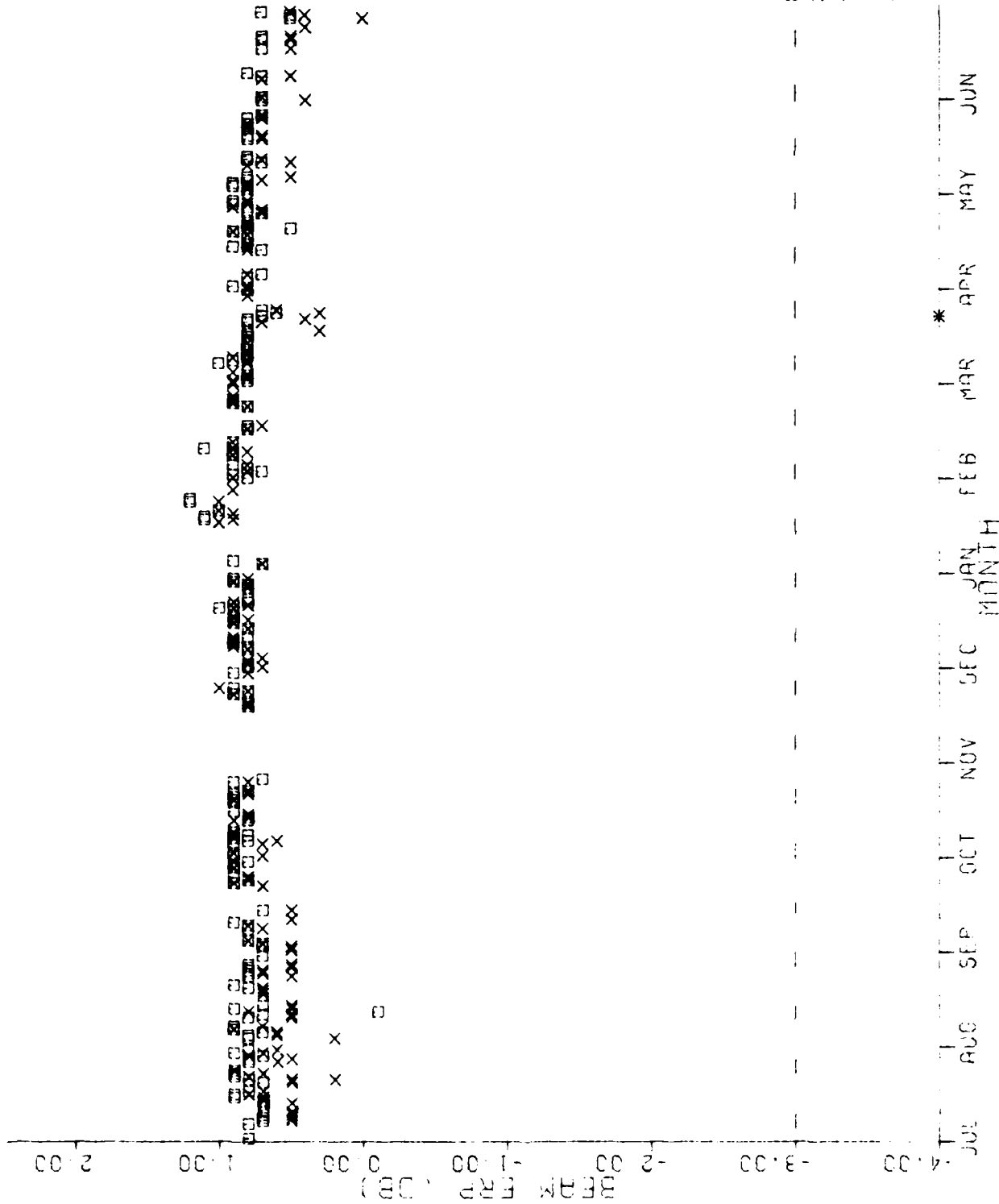


FIGURE 5. AZIMUTH MONITOR, JULY 1981-JUNE 1982, BEAM ERP PARAMETER
COMPOSITE PLOT

DATA RECORDED AND PROCESSED BY THE F40 TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N. J. 09405

WASH. HES AZ. MONITOR: JUL. 1981-JUN., 1982.

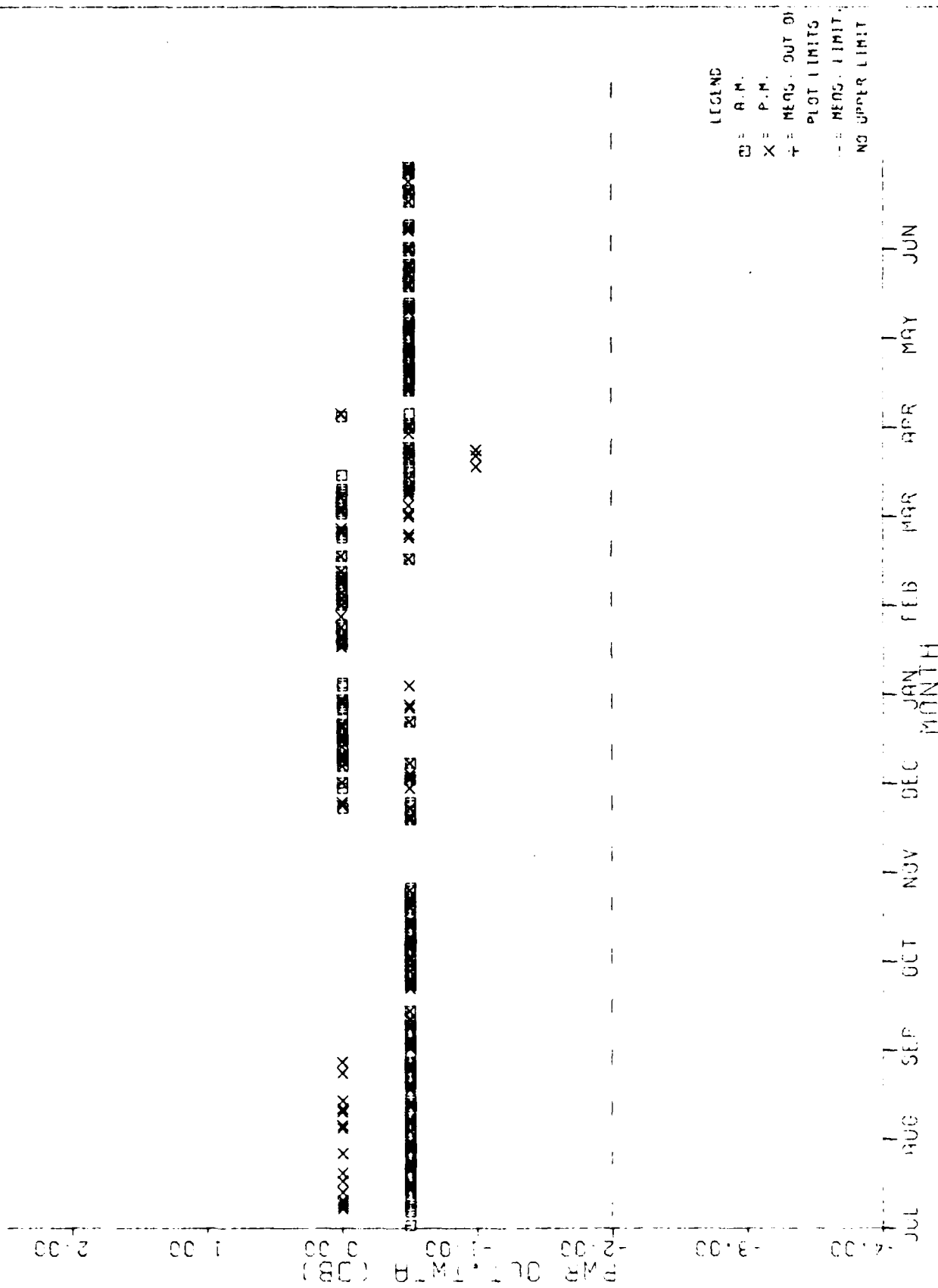


FIGURE 6. AZIMUTH MONITOR, JULY 1981-JUNE 1982, TWTA POWER OUT
PARAMETER COMPOSITE PLOT

WASH. MET. AZ. MONITOR: JUL. 1981-JUN. 1982.

DATA RECORDED AND PROCESSED BY THE FPO TECHNICIAN
CENTER ATLANTIC CITY AIRPORT, N.J. 08405

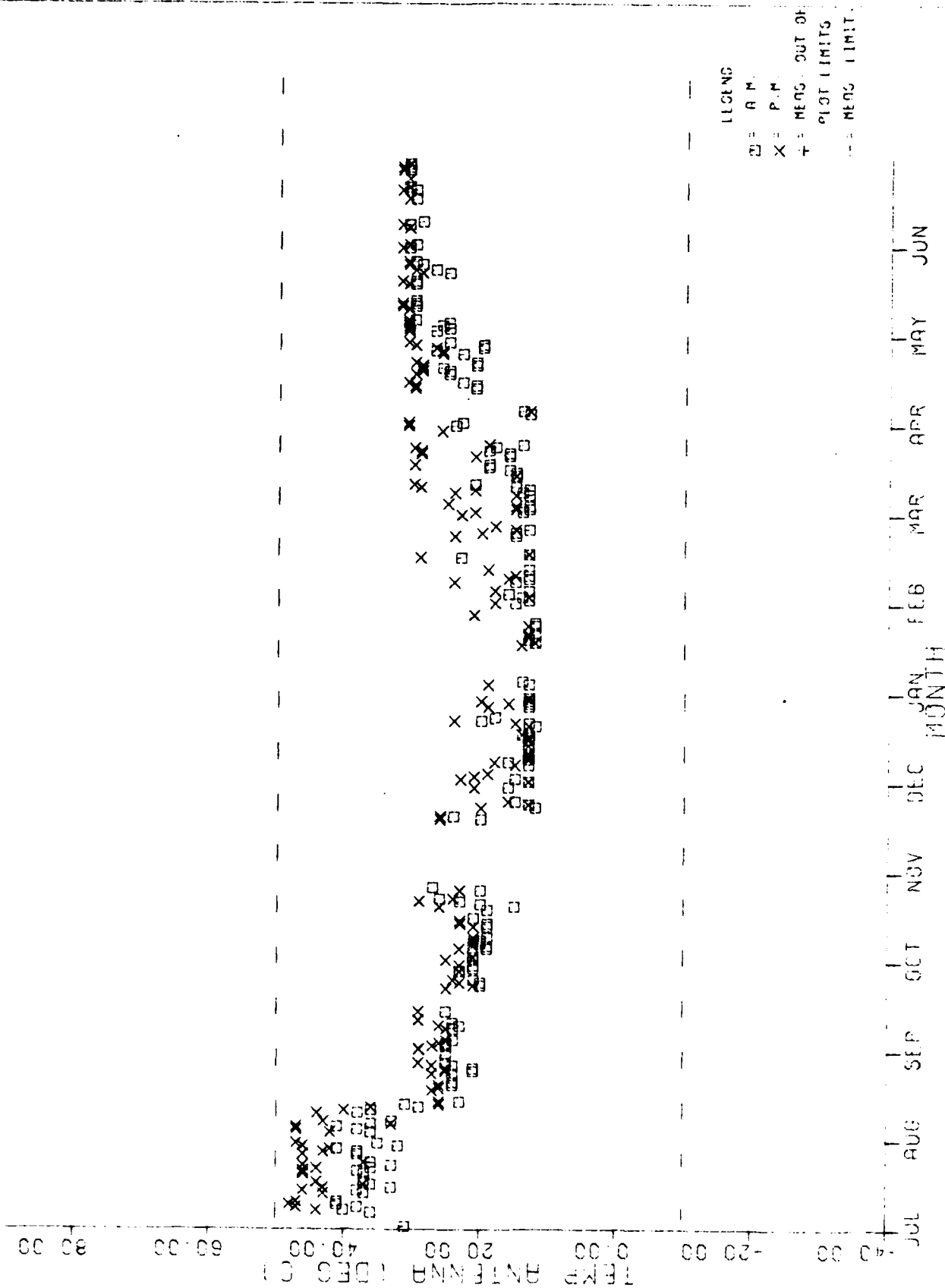
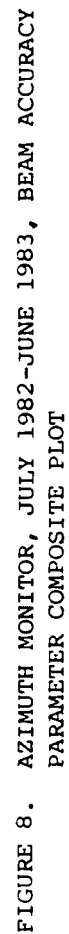


FIGURE 7. AZIMUTH MONITOR, JULY 1981-JUNE 1982, ANTENNA TEMPERATURE
PARAMETER COMPOSITE PLOT

[illegible]

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0000 0000

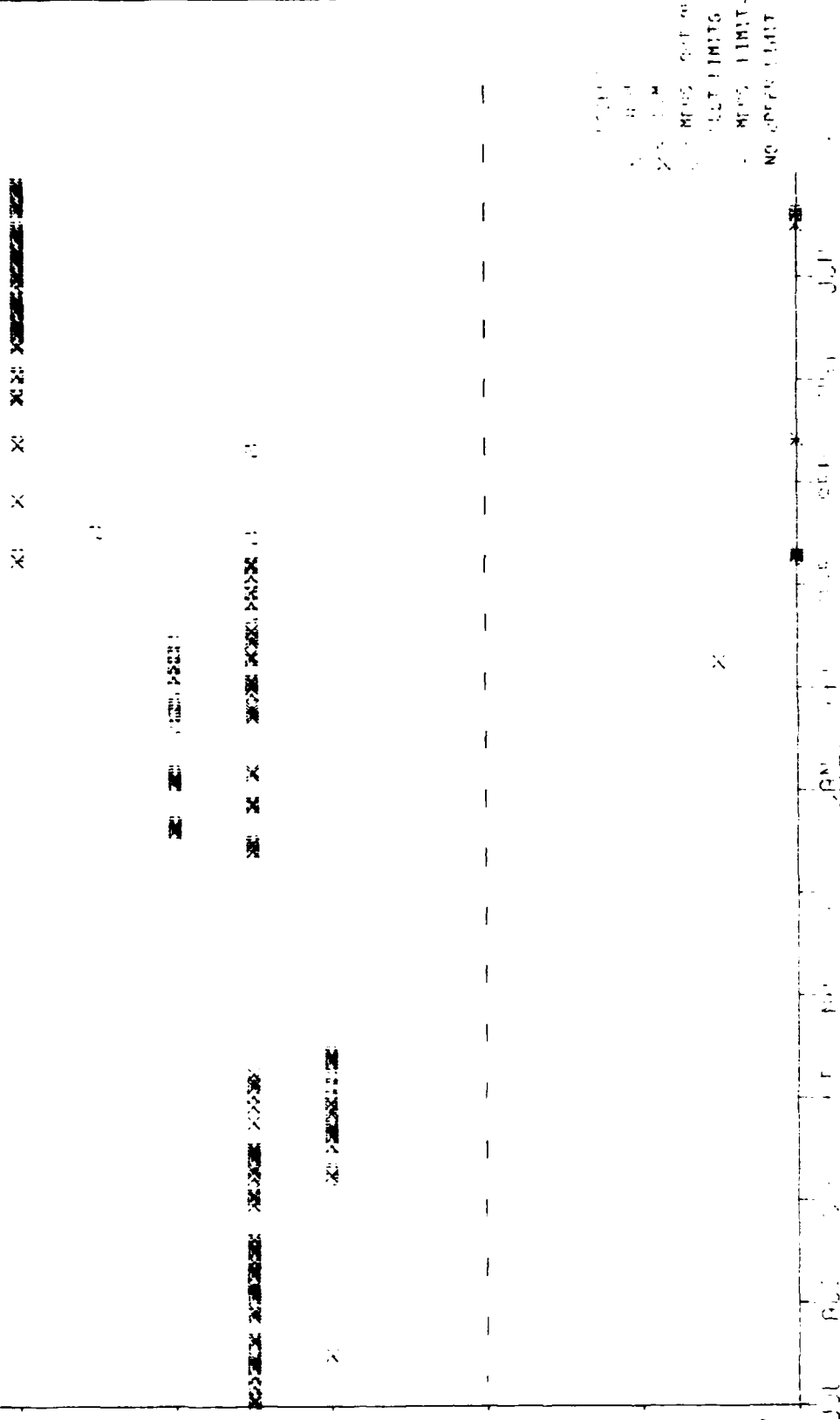
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FIGURE 9. AZIMUTH MONITOR, JULY 1982-JUNE 1983, BEAM ERP PARAMETER
 COMPOSITE PLOT

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UNITED STATES DEPARTMENT OF THE ARMY
 ARMY ENGINEERING CENTER
 FORT BELVOIR, VIRGINIA 22060

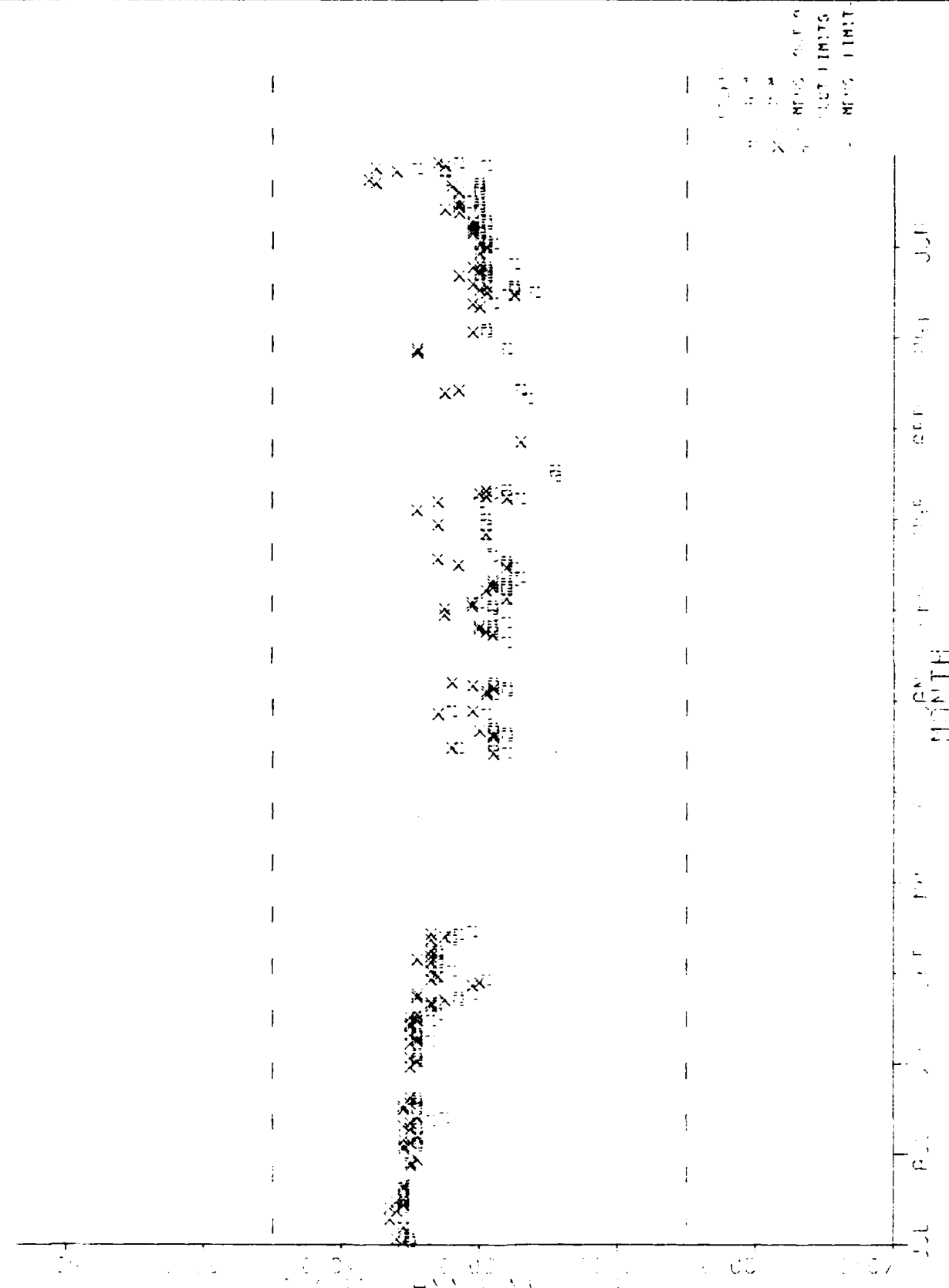


FIGURE 11. AZIMUTH MONITOR, JULY 1982-JUNE 1983, ANTENNA TEMPERATURE
 PARAMETER COMPOSITE PLOT

TABLE 4. AZIMUTH SUBSYSTEM RMS DATA YEARLY PLOTS' ANALYSIS RESULTS

Parameter	Plot	81/82 vs 82/83 Year to Year Variations		81/82 vs 82/83 Seasonal Variations		81/82 vs 82/83 Variation Patterns		81/82 vs 82/83 a.m. to a.m. Variations		81/82 vs 82/83 p.m. to p.m. Variations		81/82 a.m. to p.m. Variations		82/83 a.m. to p.m. Variations	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Beam Accuracy	Composite		X	1X		1X									
	a.m.								X				X		X
	p.m.										X		X		X
Beam ERP	Composite		X		X	2X									
	a.m.								X			3X		4X	
	p.m.										X	3X		4X	
TWT Power Out	Composite		X		X	5X									
	a.m.								X				X		X
	p.m.										X		X		X
Antenna Temperature	Composite		X	6X		6X									
	a.m.								X				X		X
	p.m.										X		X		X

Notes: Pertinent notes are indicated by numbers in the "Yes" column. The notes are given on the following pages.

TABLE 4. AZIMUTH SUBSYSTEM RMMS DATA YEARLY PLOTS'
ANALYSIS RESULTS (CONTINUED)

Note 1: In figures 4 and 8 the beam accuracy parameter data during the cold months from November through March of both years were near to, touching, or exceeding the -0.072° specification limit; while in the same plots during the hot times of the year that parameter's magnitude was closer to 0.000° or exceeded it in the positive direction. There is a relationship between the seasonal temperatures and a positiveness or negativeness of the plotted data. These two plots also indicate a slightly sinusoidal pattern with a peak to peak difference of about 0.072° except for May and June 1983, in which the parameter becomes more positive, but generally does not exceed the positive specification limit. In March and April 1983, much fewer data points are shown because of the RF SW-1 failure. During May and June 1983, the beam ERP parameter was in executive fault as a result of the "test" RF SW-1 assembly being utilized. Using the "Test" RF SW-1 assembly was the only means to keep the azimuth subsystem operating to collect equipment failure data. This also explains why the a.m. to p.m. variations in (figures D-9 and D-13) for April through June 1983, are greater than at other times over the 2-year RMMS data period. Known reasons for executive fault status are given in table 5, and a discussion on executive fault anomalies is presented in paragraph 4 of this section.

Note 2: In figure 5 the beam ERP parameter data approximated a straight line having a central tendency about $+0.75$ dB with a variation of ± 0.25 dB. Similarly, the second RMMS data year, figure 9, for that parameter's data approximated a straight line having a central tendency about $+0.5$ dB with a variation of ± 0.3 dB, except for the months March through June 1983, when the parameter was generally in executive fault status. The "test" RF SW-1 assembly was used then as it was the only means to collect failure data.

Note 3: In figures D-2 and D-6 the beam ERP parameter data both approximate straight lines, but with different central tendency values. The a.m. data (figure D-2) has an approximate central tendency value of $+0.8$ dB with a ± 0.1 dB variation. The p.m. data (figure D-6) has an approximate central tendency value of $+0.6$ dB with a ± 0.35 dB variation. The p.m. values have larger variations than the a.m. values during the warmer months of the year (July and August 1981 and June 1982). The a.m. data variation is greatest in the colder months of January through March 1982. No reasons are known for this type of variability, but all the data are within the parameter specification.

Note 4: In figures D-10 and D-14 the beam ERP parameter second year RMMS data both approximate straight lines, but with different central tendency values. The a.m. data (figure D-10) has an approximate central tendency value of $+0.6$ dB and with a ± 0.3 dB variation. The p.m. data (figure D-14) has an approximate central tendency value of $+0.5$ dB with a ± 0.4 dB variation. During the months of March through June 1983, the beam ERP parameter was mostly in executive fault status as can be seen on the plots. The p.m. data central tendency value is lower than that of the a.m. data and also has a greater variation. The warmer months of July and August 1982 indicate a wider variation for the p.m. data similar to the previous year's experience. However, the a.m. data has about the same variation throughout its nonexecutive

TABLE 4. AZIMUTH SUBSYSTEM RMMS DATA YEARLY PLOTS'
ANALYSIS RESULTS (CONTINUED)

fault data experience in the second year, unlike the first year's a.m. data experience. There are no known reasons for the variations in the second year's data, but all transmission level data are within the parameter specification. The reasons for executive fault occurrences are given in table 5.

Note 5: In figures 6, 10, D-3, D-7, D-11, and D-15 the TWTA power out parameter data are in multiple straight lines parallel to the "date" axis, which is a result of that parameter's resolution of 0.5 dB. All the parameters transmission level data are within specification the first RMMS data year with the data variations between -1.0 and 0.0 dB (figures 6, D-3, and D-7). In the second data year (figures 10, D-11, and D-15), the transmission level data are within specification with data variations between -1.0 and +1.0 dB. The reasons for the parameter executive faults are given in table 5.

Note 6: In figures 7 and 11 the antenna temperature parameter data form a slightly sinusoidal waveshape over the 2 years of RMMS data. In general, each year compares to the other in peaks and valleys by parameter magnitude and date-axis location. The peak to peak difference is about 20° C, having a maximum value of about 30° C and a minimum value of about 10° C. An exception occurs during July and August 1981, where the plots in figures 7, D-4 and D-8 show the performance of the poorly operating antenna enclosure air conditioning system. The p.m. data figure D-8 show the higher summer afternoon environmental temperatures elevated the antenna enclosure interior temperature.

4. The out-of-tolerance conditions are listed in table 5 for the four azimuth subsystem RMMS data parameters which were plotted. It should be noted that there are anomalies in the corresponding beam accuracy parameter data from the different data sets due to recording instrumentation operating characteristics. The executive monitor for this parameter causes an executive fault when the parameter exceeds a +0.072° magnitude. The technical performance record indicates one-half of the magnitude due to an oversight in the design of a PROM integrated circuit chip. The AZ subsystem PROM was made identical to its counter part PROM in the EL subsystem. The angle value stored in the AZ PROM should have been double the EL PROM angle value.

TABLE 5. AZIMUTH SUBSYSTEM 1981/1983 RMMS
DATA OUT-OF-TOLERANCE CONDITIONS

<u>Parameter</u>	<u>Data</u>	<u>Parameter Value</u>	<u>Recorded Reason for Condition</u>
Beam Accuracy	7/14/81	-0.492	None
	12/17/81	-0.076	None, no executive fault shown on analog recorder tracing
	12/21/81	-0.080	None, no executive fault shown on analog recorder tracing
	12/31/81	-0.076	None, no executive fault shown on analog recorder tracing
	1/19/82(a.m.)	-0.076	None, no executive fault shown on analog recorder tracing
	1/19/82(p.m.)	-0.076	None, no executive fault shown on analog recorder tracing
	1/21/82	-0.076	None, no executive fault shown on analog recorder tracing
	1/22/82	-0.076	None, no executive fault shown on analog recorder tracing
	1/25/82	-0.084	Sleet on radome. Executive fault shown on analog recorder
	3/9/82	-0.080	None, no executive fault shown on analog recorder tracing
	3/10/82	-0.076	None, no executive fault shown on analog recorder tracing
	3/24/82	+0.452	None, no log data recorded on this date
	3/25/82	+0.192	None
	8/13/82		None
	9/17/82		None
	2/8/83		Scan modulator executive faults
	3/9-11/83		RF SW-1 assy. failed
	4/13-14/83		RF SW-1 assy. failed
	4/27/83		Test RF SW-1 assy utilized
			(only RF SW-1 assy available))
	6/17-21/83		Site power outage (only one phase from airport)
Beam ERP	3/24/82		None, no log data recorded on this date
	2/8/83		Scan modulator executive faults
	3/8-11/83		RF SW-1 assy. failed
	3/28/83		RF SW-1 assy. failed
	4/13-14/83		RF SW-1 assy. failed
	4/27-6/30/83		Test RF SW-1 assy. utilized
			(only unit available)

TABLE 5. AZIMUTH SUBSYSTEM 1981/1983 RMMS
DATA OUT-OF-TOLERANCE CONDITIONS (CONTINUED)

<u>Parameter</u>	<u>Data</u>	<u>Parameter Value</u>	<u>Recorded Reason for Condition</u>
TWTA Power Out	2/8/83		Occurred during scan modulator executive faults
	3/9-11/83		Site down due to RF SW-1 assy. failure
	4/13/83		Site down due to RF SW-1 assy. failure
	6/17-21/83		Site power outage (only one phase from airport)
Antenna Temperature	None		

The Russtrak recorder parameter magnitude sensitivity setting could not be resolved less than $+0.080^\circ$, but the alarm limit setting was $+0.072^\circ$ for an executive fault. During the 1981/1982 RMMS data year, executive faults were occurring from December 1981 through March 1982, as seen in figure 4. The values of these executive faults, which are listed in table 5, just exceed the specification limit of -0.072° , but do not exceed -0.080° . This anomaly in data recording resulted in a decreased number of executive faults in the analog Russtrak recorder data. When no executive fault was shown on the Russtrak recorder, the site person did not know it occurred and, consequently, could not report pertinent information in the log data. The actual parameter readings listed in table 5 were taken from computer listings of the RMMS plotted data.

2. Elevation Subsystem.

a. The method of RMMS data examination for the EL subsystem is similar to the method used for the azimuth subsystem section described in paragraph 1a.

b. The corresponding composite a.m. and p.m. plots are shown in figures 12 through 19; the related individual a.m. and p.m. plots are shown in appendix D, figures D-17 through D-32. The analyses of the plots are referenced in table 6 to the text notes listed below in paragraph c. The out-of-tolerance conditions for the elevation subsystem plots are listed in table 7.

c. The RMMS data plots analyses are presented in table 6 reference note numbers.

SUMMARY.

Both the AZ and EL subsystems experienced chargeable and nonchargeable equipment failures with some of each causing subsystem downtime. It should be noted that some chargeable equipment failures caused no subsystem downtime, while some nonchargeable equipment failures caused subsystem downtime. Two of the six chargeable failures in the AZ subsystem and two of the eight chargeable failures in the EL subsystem, or approximately 28.6 percent of the fourteen MLS chargeable equipment failures in the 2.5-year analysis period were related to the air conditioner/heater assembly equipment. Additionally, one of the five or 20 percent of system nonchargeable equipment failures related to the same assembly equipment. Three of the eight or 37.5 percent of the EL subsystem chargeable equipment failures related to the subsystem's vulnerability to physical abuse from airport construction and maintenance equipment, and repairmen. Two of these chargeable failures were interrelated and resulted in extensive subsystem downtime and expensive equipment replacement costs.

The site power outages were mostly due to airport emergency power system tests and commercial power outages. The MLS availability is somewhat related to bad weather conditions. Engineering investigations have developed materials and equipment to significantly improve the MLS availability in bad weather conditions. Airport maintenance moving vehicles at the MLS EL site generally caused short duration executive faults allowing for automatic subsystem restart. Some airport construction and maintenance vehicles in motion at the

DATA RECORDED AND PROCESSED BY THE F-40 TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

WASH. MISC FL. MONITOR: JUL., 1981-JUN., 1982.

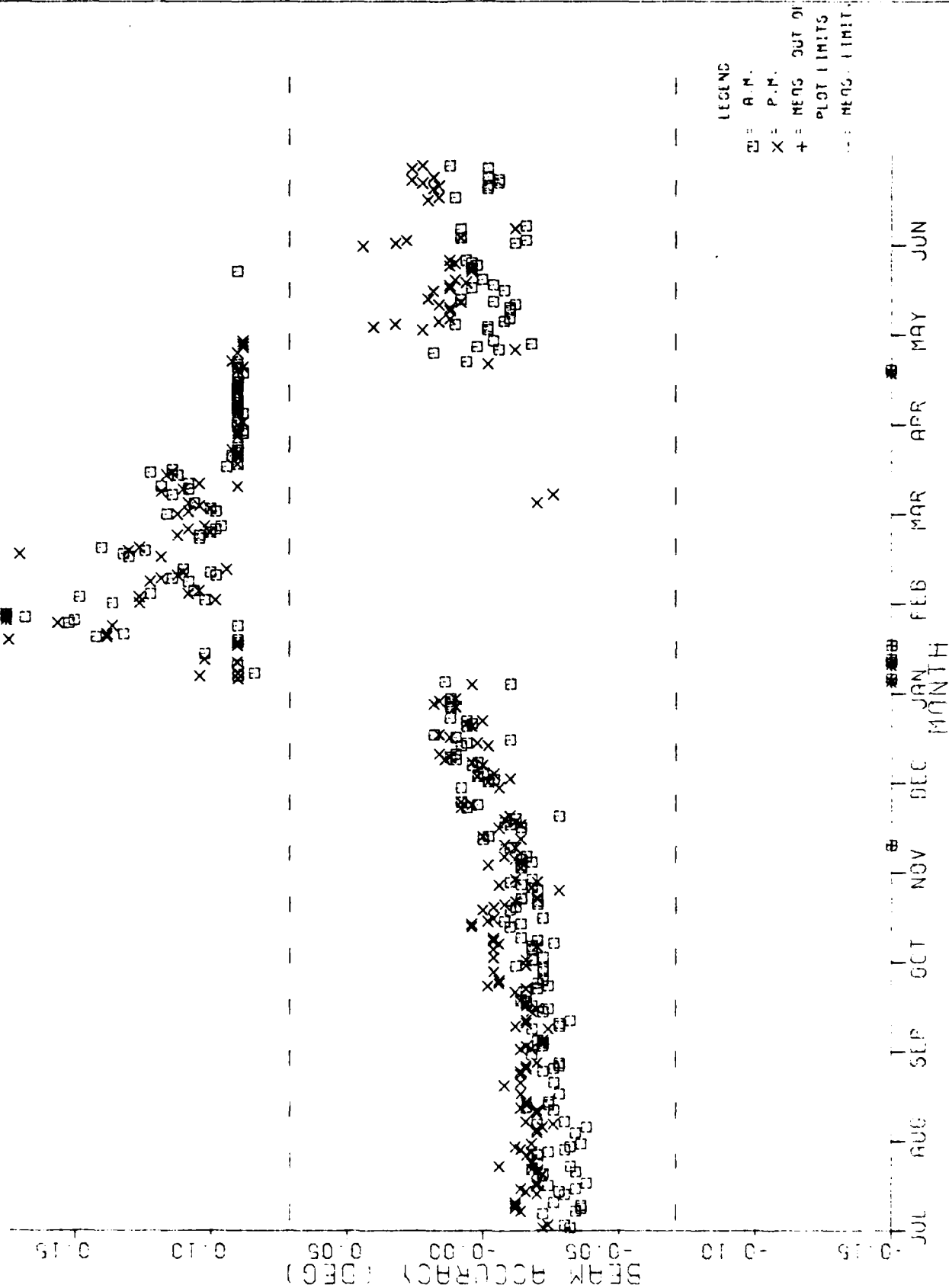


FIGURE 12. ELEVATION MONITOR, JULY 1981-JUNE 1982, BEAM ACCURACY
PARAMETER COMPOSITE PLOT

DATA RECORDED AND PROCESSED BY THE FAN TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N.J. 08403

WASH. MILES EL. MONITOR: JUL., 1981-JUN., 1982.

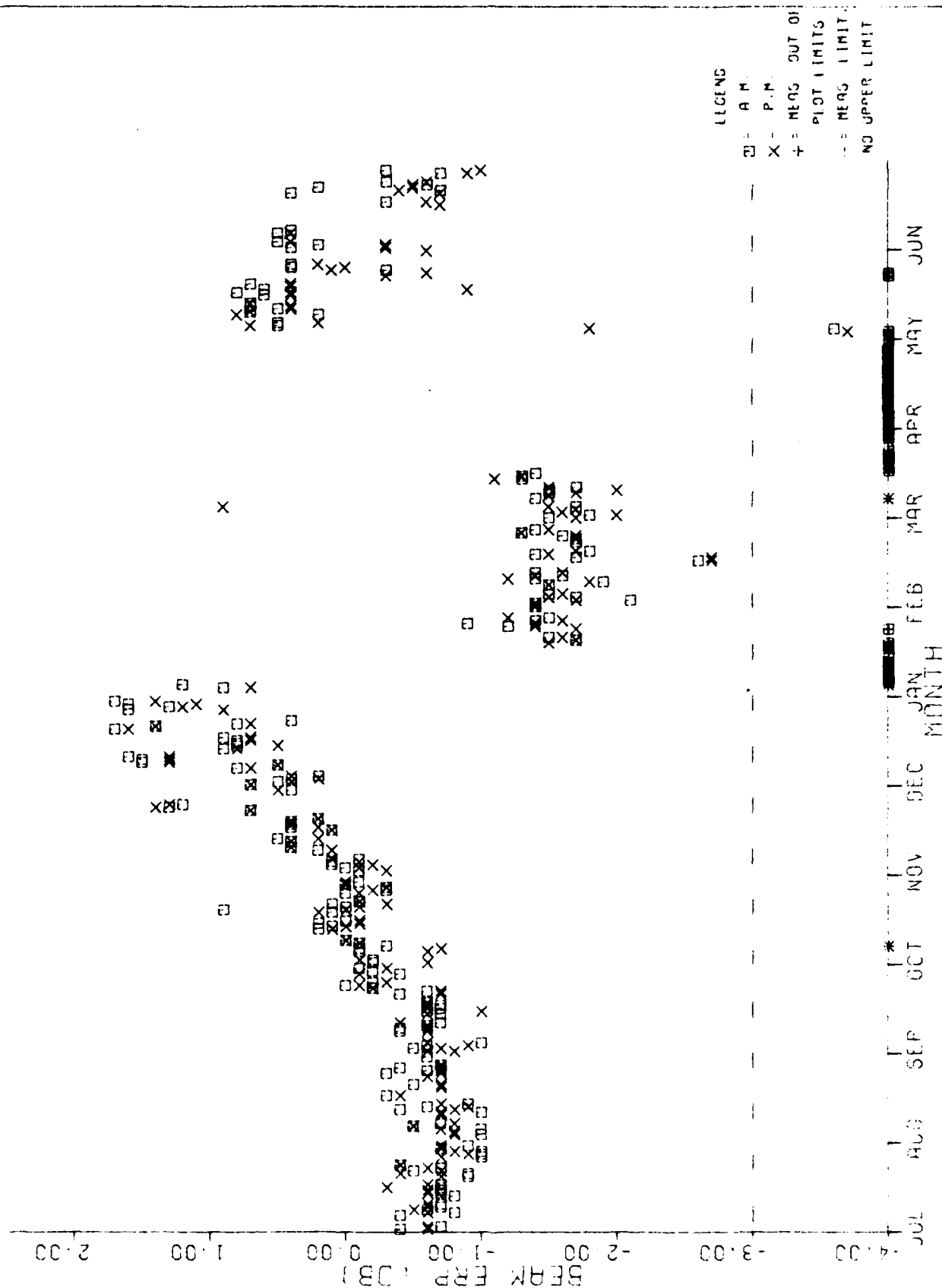


FIGURE 13. ELEVATION MONITOR, JULY 1981-JUNE 1982, BEAM ERP PARAMETER
COMPOSITE PLOT

WASH. MTS FL. MONITOR: JUL., 1981-JUN., 1982.

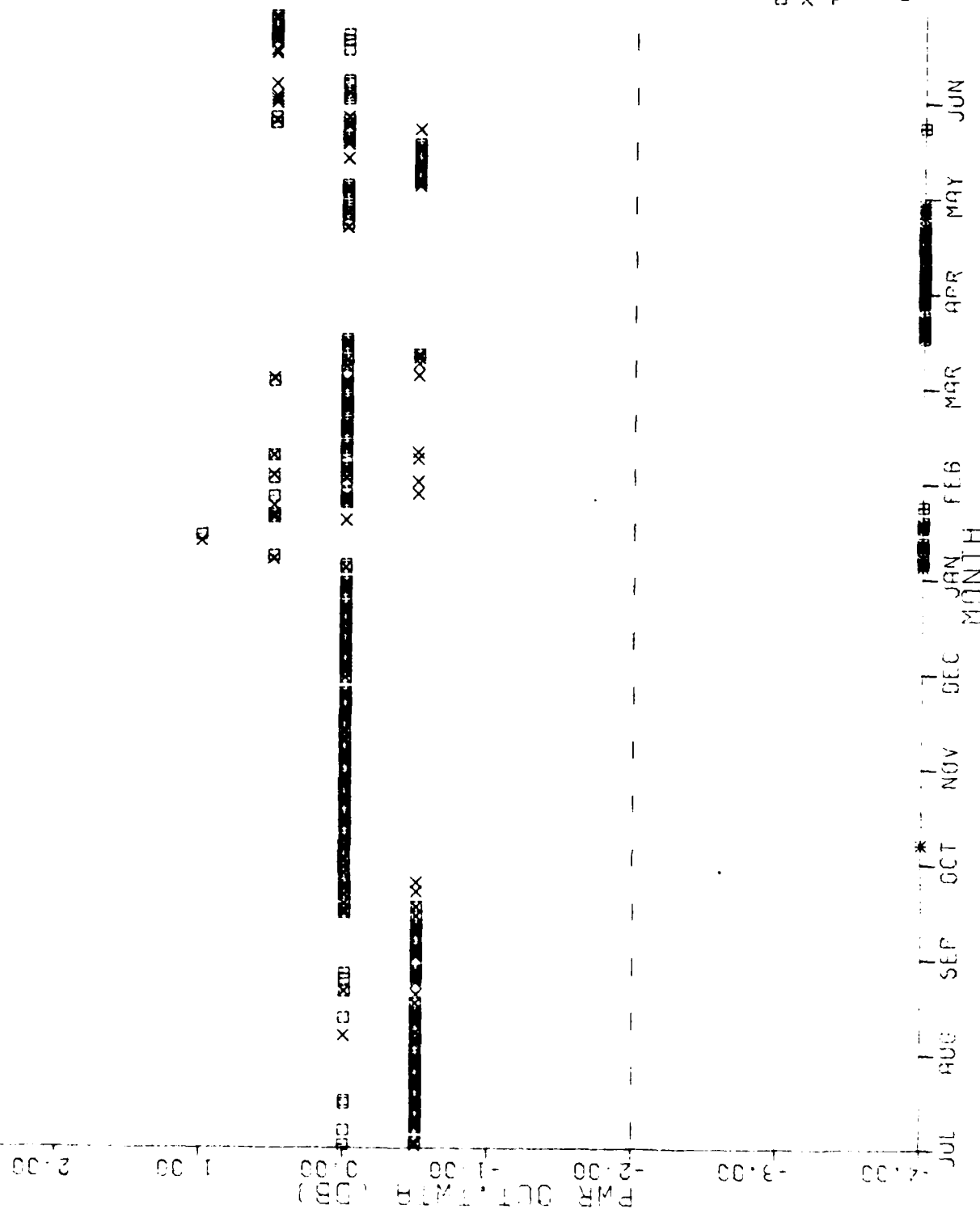


FIGURE 14. ELEVATION MONITOR, JULY 1981-JUNE 1982, TWTA POWER OUT
PARAMETER COMPOSITE PLOT

DATA RECORDED AND PROCESSED BY THE FNN TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

WASH. MET. ST. MONITOR: JUL., 1981-JUN., 1982.

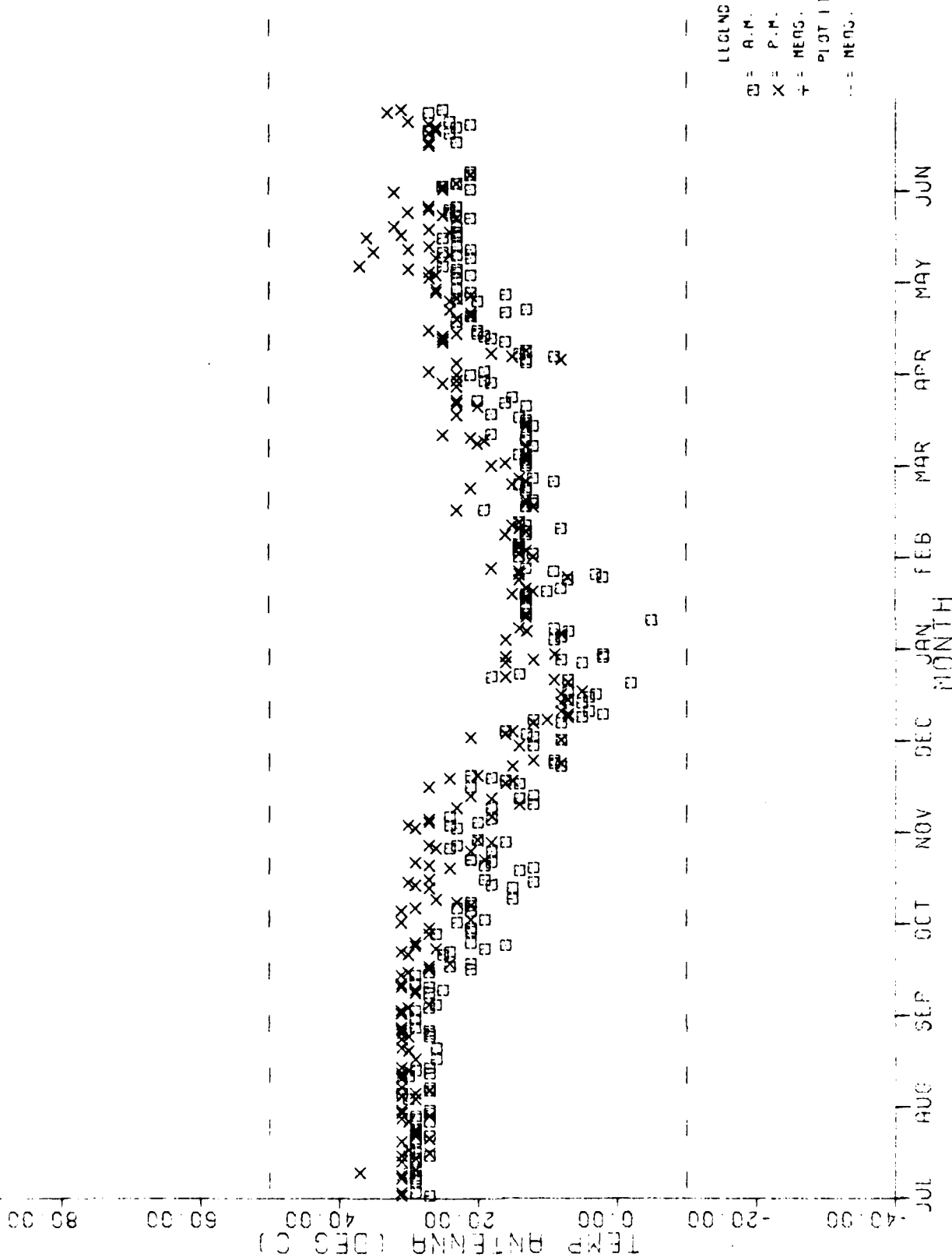


FIGURE 15. ELEVATION MONITOR, JULY 1981-JUNE 1982, ANTENNA TEMPERATURE
PARAMETER COMPOSITE PLOT

ELEVATION MONITOR, JULY 1982-JUNE 1983, BEAM ACCURACY
 COMPOSITE CITY REPORT, N. 1000

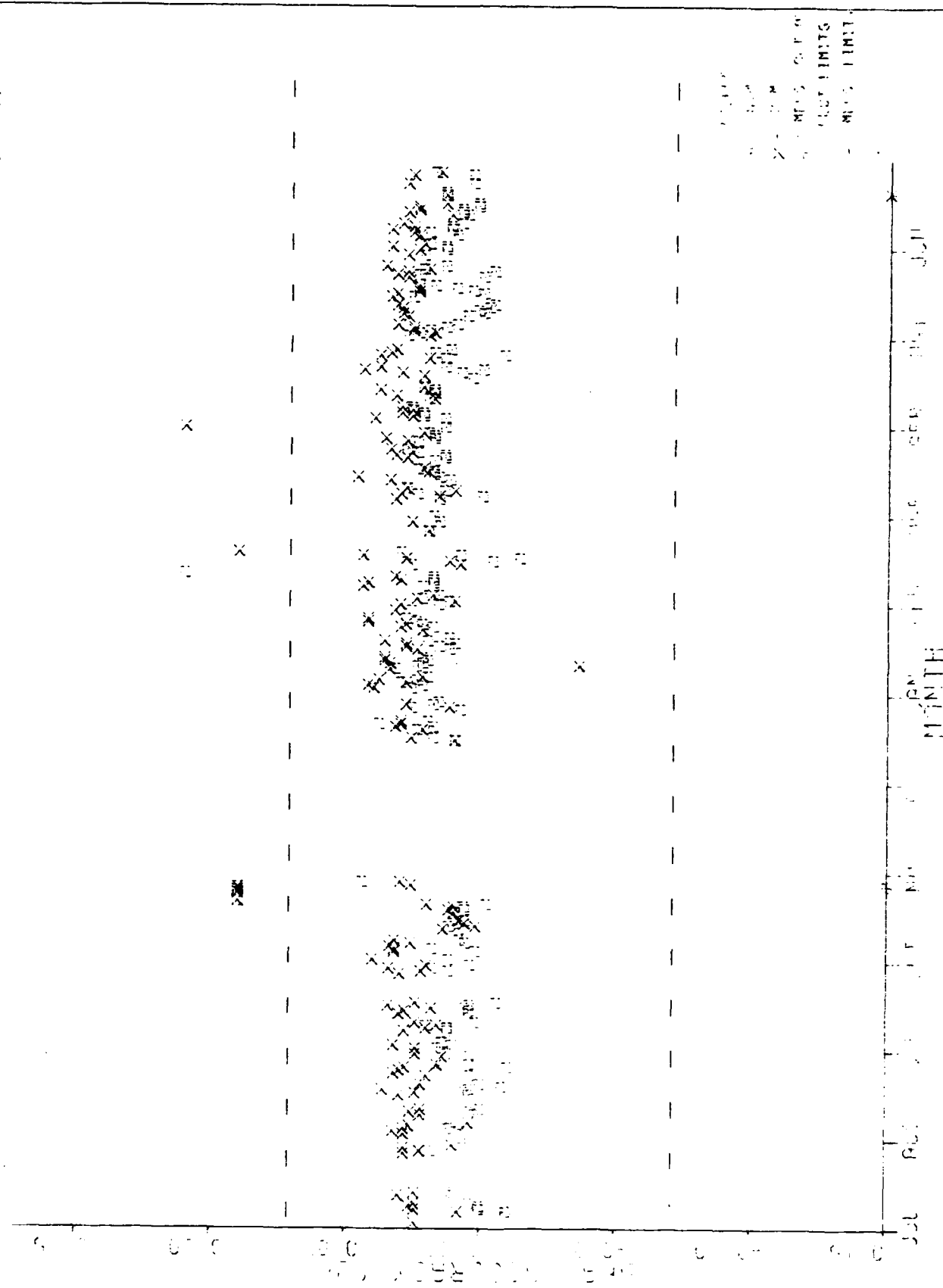


FIGURE 16. ELEVATION MONITOR, JULY 1982-JUNE 1983, BEAM ACCURACY
 PARAMETER COMPOSITE PLOT

HIGH BEAM ACCURACY MONITOR JULY 1982-JUNE 1983
 THE BEAM ACCURACY MONITOR JULY 1982-JUNE 1983
 THE BEAM ACCURACY MONITOR JULY 1982-JUNE 1983

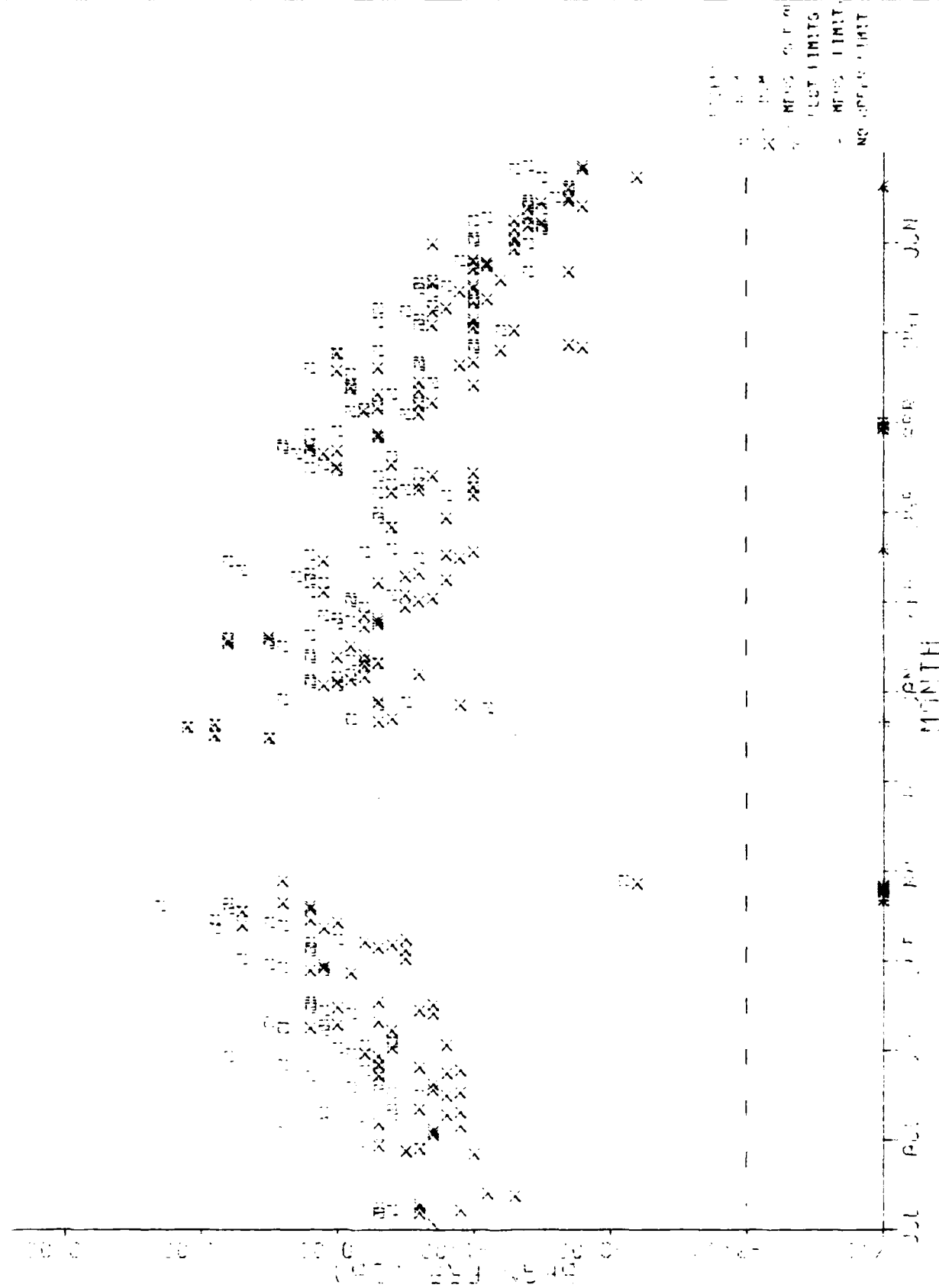


FIGURE 17. ELEVATION MONITOR, JULY 1982-JUNE 1983, BEAM ACCURACY
 PARAMETER COMPOSITE PLOT

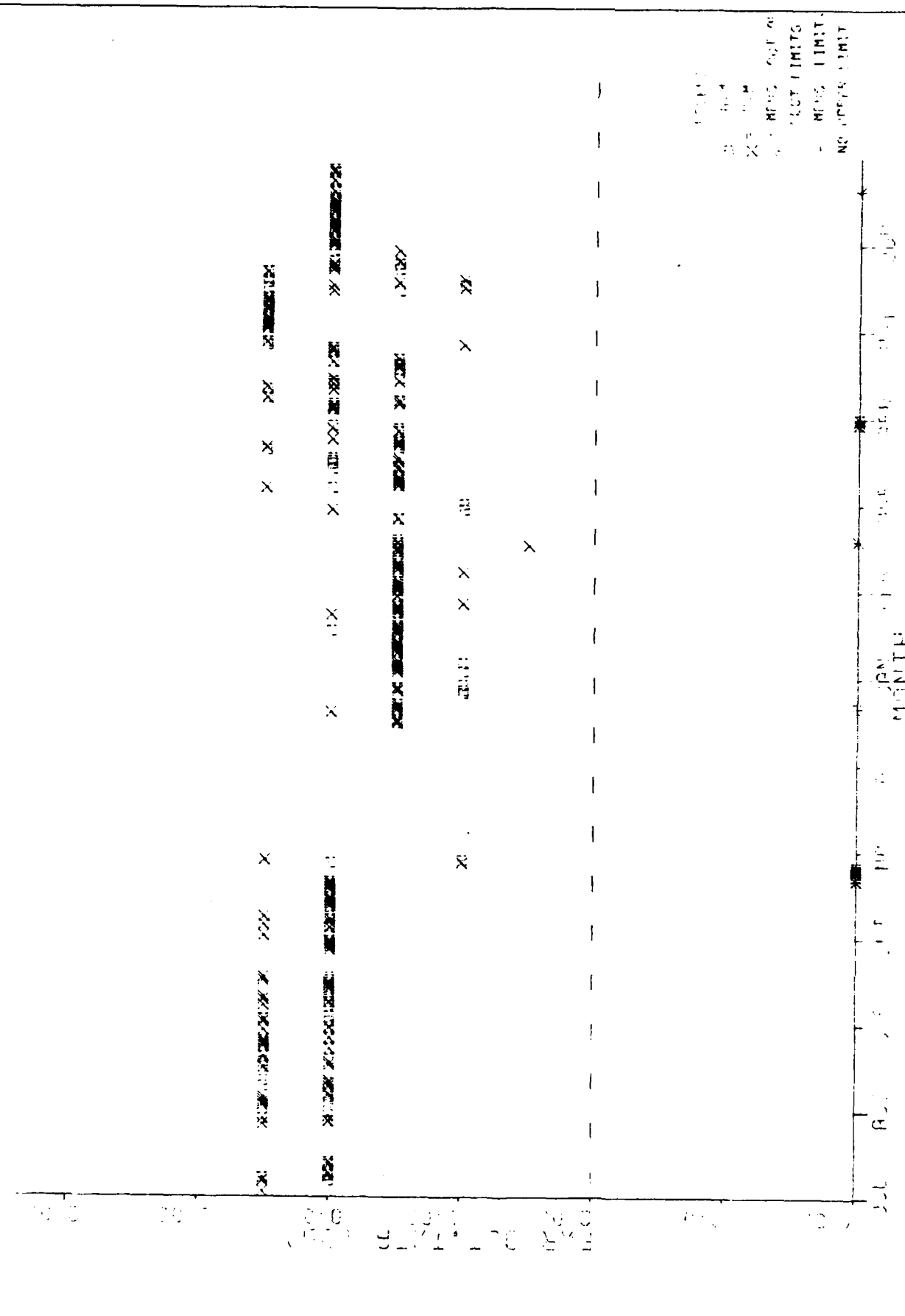


FIGURE 18. ELEVATION MONITOR, JULY 1982-JUNE 1983, TWTA POWER OUT
 PARAMETER COMPOSITE PLOT

JOHN R. ... AND PAGE ... THE ...
 ... CITY ...

MINIATURE JULY 1982-JUNE 1983

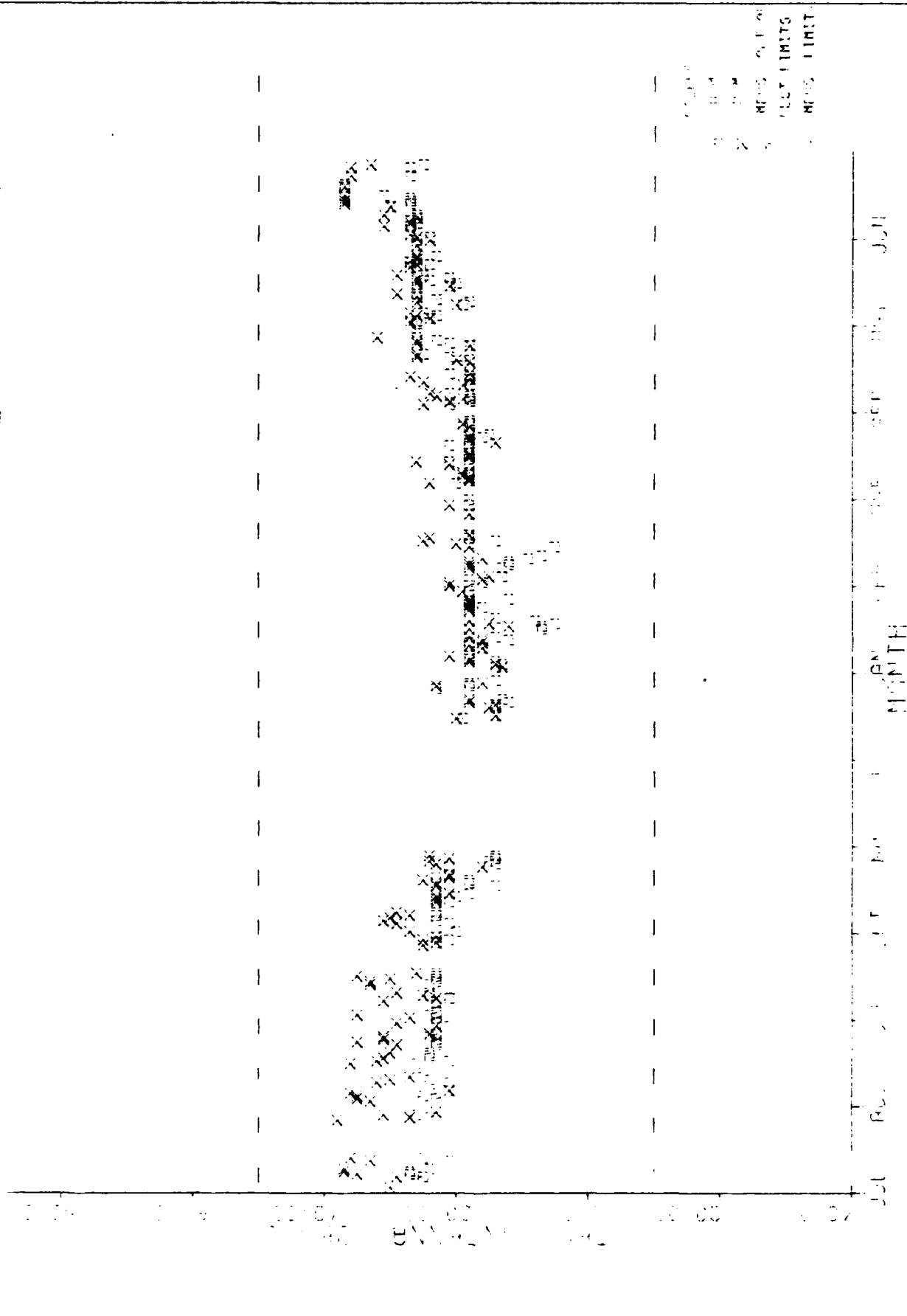


FIGURE 19. ELEVATION MONITOR, JULY 1982-JUNE 1983, ANTENNA TEMPERATURE
 PARAMETER COMPOSITE PLOT

TABLE 6. ELEVATION SUBSYSTEM RMS DATA YEARLY PLOTS' ANALYSIS RESULTS

Parameter	Plot	81/82 vs 82/83 Year to Year Variations		81/82 vs 82/83 Seasonal Variations		81/82 vs 82/83 Variation Patterns		81/82 vs 82/83 a.m. to a.m. Variations		81/82 vs 82/83 p.m. to p.m. Variations		81/82 a.m. to p.m. Variations		82/83 a.m. to p.m. Variations	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Beam Accuracy	Composite		1X		1X		1X								
	a.m.											2X		3X	
	p.m.											2X		3X	
Beam ERP	Composite	4X		4X		4X									
	a.m.							5X					X		X
	p.m.									5X			X		X
TWTA Power Out	Composite		6X		6X		6X								
	a.m.								6X				6X		6X
	p.m.												6X		6X
Antenna Temperature	Composite	7X		7X		7X									
	a.m.							8X				10X		10X	
	p.m.									9X		10X		10X	

Notes: Pertinent notes are indicated by numbers in the appropriate column. The notes are given on the following pages.

TABLE 6. ELEVATION SUBSYSTEM RMMS DATA YEARLY PLOTS'
ANALYSIS RESULTS (CONTINUED)

Note 1: In figures 12 and 16, the beam accuracy parameter data did not behave like the AZ subsystem's beam accuracy parameter data in that the data approximated a straight line (rather than slightly sinusoidal) following the installation of the new waveguide during May 1982. Prior to the damaging incident, the original waveguide data may suggest a slightly sinusoidal waveshape, but the amount of data in that last half of 1981 is inadequate to be conclusive. The differences between the a.m. and p.m. data magnitudes are discussed in the following notes 2 and 3. No RMMS data were collected during November 1982 while an azimuth site power line was being repaired (the EL subsystem was shut off).

Note 2: Note 1 also applies here. In addition, the RMMS data (figures D-17 and D-21) following the new waveguide's installation (May 1982) was about 0.02° in the p.m. and about 0.00° in the a.m. With the original waveguide, the RMMS data in these two figures crossed about November 1981 with the changing seasons. In the cold months the p.m. data were slightly negative of the a.m. data; the opposite is true in the warmer months. No reason can be deduced for the crossover in magnitudes of the a.m. and p.m. data. The p.m. data collected with the new waveguide was more positive than the a.m. data for over a year (see note 3).

Note 3: Note 2 also applies here. The RMMS p.m. data (figure D-29) central tendency difference from the a.m. data (figure D-25) was about $+0.02^\circ$. However, during the 1981/1982 RMMS data year with the original waveguide, the difference of the p.m. data (figure D-21) central tendency from the a.m. data (figure D-17) central tendency decreases from $+0.015^\circ$ to $+0.01^\circ$. There is not enough original waveguide period RMMS data to draw a trending conclusion.

Note 4: Composite yearly data plots (figures 13 and 17) placed end-to-end indicate a slightly sinusoidal waveshape pattern. In both years of RMMS data, during the cold months of December and January, the beam ERP parameter magnitude peaks positive slightly above 1.0 dB, while in the hot months of June, July, and August the most negative peak magnitude was about -2.0 dB. No RMMS data could be collected during November 1982 when both subsystems were not operating due to a power line to the azimuth site being replaced. The effects of operating the subsystem with a damaged waveguide on this parameter are seen in figures 13, D-18, and D-22 during the months of January through March 1982. In this time period water and/or water vapor would take the place of the leaking pressurized nitrogen gas from the waveguide resulting in lowered beam ERP levels.

Note 5: Note 4 also applies here. In addition, by comparing figure D-18 (a.m.) with D-26 (a.m.), and D-22 (p.m.) with D-30 (p.m.), the data show larger variations for May-June 1982 than for May-June 1983, although the levels remained well within tolerance.

Note 6: The shelter's air conditioner failed and was out of service from July 1982 through June 1983. The shelter's exhaust fan ran continuously during the

TABLE 6. ELEVATION SUBSYSTEM RMMS DATA YEARLY PLOTS'
ANALYSIS RESULTS (CONTINUED)

hot weather months (May-September), keeping the inside temperature below the TWTA temperature specification upper limit of 140° F (60° C). The lower TWTA specification limit is 32° F (0° C). In this temperature range the TWTA power out is specified to vary only +1.0 dB. The TWTA power out parameter is sensed by an RF detector, amplified by a transistor amplifier, and, subsequently, fed into an analog to digital converter in the executive monitor assembly. The converter resolution is indicated by the 0.5 dB data steps in figures 14, 18, D-19, D-23, D-27, and D-31. During the hot months of May through September, the environmental temperature did not go above 97° F (36.1° C). It varied from the low 70's through the low 90's during the day, while at night it was generally in the 60's. In the hot months of July through September 1982, the shelter's interior temperature was probably hotter than during the same period in 1981 when the shelter's air conditioner was working, thereby, lowering the inside temperature. It is assumed the change in interior temperature affected the sensing amplifier circuit components more than it affected the TWTA. The effects of the shelter's interior temperature on the RF detector's amplifier are thought to have been the cause of TWTA power out RMMS data changes, especially since the amplifier is physically located at the top of a tall rack (near the roof of the shelter). In the heat of the afternoon, the RMMS data was negative, indicating lower power out. While in the morning, when it was cooler, the data was positive, indicating more power out. The apparent susceptibility of the sensing circuitry to heat is believed to have changed the RMMS data variations rather than caused any change in the TWTA equipment operation. Note that the transmission data were well within the parameter's specification. Known reasons for executive faults indicated on the plots are listed in table 6.

Note 7: In figures 15 and 19, the antenna temperature parameter data has a slightly sinusoidal waveshape when placed end-to-end and time ordered, with a peak-to-peak difference of about 40° C. The maximum positive value was about +40° C peaking positive in the hot months of May through August, while the most negative value was about 0° C occurring during the coldest months of December through March. No data were collected during November 1982 due to a power outage at the azimuth site.

Note 8: Refer to preceding note 7 and the following note 9 for comparison details of the composite and p.m. plots, respectively. In figure D-20, the 1981/1982 plot peak-to-peak variation is 25° C (30° C to 5° C). While in figure D-28, the 1982/1983 plot peak-to-peak variation is only 20° C (30° C to 10° C). The external temperatures were similar from year to year and season to season.

Note 9: Refer to preceding notes 7 and 8 for comparison details of the composite and a.m. plots, respectively. In figure D-24, the 1981/1982 plot peak-to-peak variation is 32° C (37° C to 5° C) and in figure D-32, the 1982/1983 plot the peak-to-peak variation is 29° C (39° C to 10° C).

Note 10: In figures D-20, D-24, D-28, and D-32 the summer of 1982 antenna temperature parameter had a higher peak p.m. temperatures than peak a.m. temperature by about 15° C (40° C to 25° C). It is curious to note that in the other two periods of outdoor heat (summers of 1981 and 1983) covered in part by the RMMS data, the a.m. to p.m. peak antenna parameter data (figures 15 and 19) are approximately the same. The outside environmental temperatures for all three summers were approximately the same (on the average). The failure of the shelter's air conditioning system in July 1982 (that endured until June 1983) is the only failure that could apply to this anomaly in antenna parameter data from that of the other two summer periods. It is important to mention that the antenna temperature parameter data was always well within the specification limit.

TABLE 7. ELEVATION SUBSYSTEM 1981/1983 RMMS DATA OUT-OF-TOLERANCE CONDITIONS

<u>Parameter</u>	<u>Data</u>	<u>Recorded Reason for Condition</u>
Beam Accuracy	11/10/81	Maintenance tests.
	1/5-6/82	Power cable to site cut by trencher.
	1/7-31/82	Damaged waveguide problems.
	2/1-31/82	Damaged waveguide problems.
	3/1-31/82	Damaged waveguide problems. One good set of data is indicated on 3/8/82 (p.m. due to monitor pole beam accuracy parameter testing.
	4/1-30/82	Damaged waveguide problems. Parameter occasionally appears satisfactory right after waveguide purged with air or nitrogen in the a.m.
	5/24/82	New waveguide being electrically tied into elev. subsystem.
	10/22-28/82	Site off due to site power problem.
	2/11/83	None.
	2/18/83	Rezeroed beam accuracy parameter.
	4/1/83	None. Test RF SW-1 assy utilized.
	6/21/83	None.
Beam ERP	1/5-20/82	
	1/20-3/16/82	Waveguide problem. Site power off or in test mode.
	3/16-5/5/82	Site in test mode and parameter operating close to its spec limit of -2 dB.
	10/22-28/82	Site in test mode while attempts were made to repair waveguide.
	12/22/82	Site in test mode while attempts were made to repair waveguide.
	3/31-4/1/83	Site turned off (power problem).
	10/7/81	None.
	1/5-21/82	Test RF SW-1 assy utilized (only one available).
TWTA Power Out	3/16-4/30/82	None.
	5/25/82	None.
	10/22-28/82	Site power off initially: site in test mode other times.
	12/22/82	TWTA turned off most of time. Limited on time during repair work. Site in test mode.
	2/18/83	None.
	3/31-4/2/83	Site not transmitting, AS site power problem.
	6/21/83	None.
		None.

TABLE 7. ELEVATION SUBSYSTEM 1981/1983 RMMS DATA OUT-OF-TOLERANCE
CONDITIONS (CONTINUED)

<u>Parameter</u>	<u>Data</u>	<u>Recorded Reason for Condition</u>
Antenna Temperature	1/5-6/82	Power cable to site cut by trencher.
	4/19-20/82	Power turned off. Waveguide repairs.
	3/31-4/1/83	None.
	6/21/83	EL subsystem in executive fault due to AZ subsystem problem.

EL site caused physical damage to that subsystem. The origins of several executive faults were unknown, but they may have been related to environmental causes.

The AZ subsystem synchronization signal losses to the EL subsystem resulted from the AZ subsystem equipment failures, AZ site power losses, AZ site engineering changes tests, AZ subsystem executive faults due to bad weather, and radomes maintenance.

The plotted RMMS parameters were operating within specification the vast majority of the time. The causes of the out-of-tolerance conditions were identified in most of the events when log data were kept. Trends, data variations, and variation patterns were identified from the yearly plots for the 2 years of RMMS data presented. Their relationships with the identified equipment failures, DCA temperature conditions throughout the year, and time of day were developed.

CONCLUSIONS

1. Several of the failures resulted from the use of non-MIL Spec parts, as well as from engineering and test and evaluation activities which required adjustments and removal of assemblies and modules.
2. The Microwave Landing System (MLS) system had a good hardware performance during the 2.5-year test period with only two chargeable equipment failures causing system downtime and eight other chargeable equipment failures causing no system downtime.
3. There were no equipment failure modes in the MLS for the test period.
4. The buried cable and waveguide for the MLS were vulnerable to physical abuse from airport construction and maintenance equipment and repairmen.
5. The need for air conditioner/heater assembly equipment may not be necessary for this MLS location. Only fans may be required.
6. There were many power outages due to airport emergency power system tests and commercial power outages. A uninterruptable power source (UPS) power system of 2-hour duration would have reduced the MLS power outage related downtime between 75 and 94 percent (uncertainty due to recording instrumentation inaccuracies).
7. The MLS operation was somewhat sensitive to bad weather, i.e., sometimes it would go into executive fault. Its sensitivity to precipitation was reduced by increasing the vertical aperture of the monitor pole antenna during an engineering test.
8. A suspected manufacturing defect in the beam antenna radome caused a fire.

9. The radio frequency switch assembly failed many times due to its sensitivity to intermittent power supply levels.
10. Executive monitor failures were chargeable, but those that occurred did not cause system downtime.
11. MLS data link lines (as installed) were subject to crosstalk from non-MLS's which caused system downtime.
12. The MLS enclosures climate-control air conditioner/heater assembly equipment water seals were not installed properly.
13. The MLS had a significant number of executive faults which did not automatically clear and required manual intervention to reset the system.
14. The plotted Remote Maintenance Monitoring System (RMMS) data parameters year to year, season by season, and morning to night comparisons indicate Washington National Airport (DCA) temperature and time of day had little impact on the MLS's operation. All four plotted parameters indicated within specification operations regardless of the airport temperature or time of day.
15. RMMS data can be used for indications of equipment failures (hard or soft) and adverse environmental effects.

RECOMMENDATIONS

If the following recommendations are implemented, this Microwave Landing System (MLS) system should make a good candidate for a low maintenance production system.

1. The MLS's buried cable and waveguide should be examined for ways to decrease their vulnerability to physical abuse from airport construction and maintenance equipment and repairmen.
2. A uninterruptable power source (UPS) power system should be included at each subsystem site to increase MLS operational reliability and availability.
3. The MLS should be designed to eliminate its sensitivity to environmental temperature to preclude the use of air conditioner/heater assembly equipment.
4. The reliability of the MLS executive monitors should be increased to improve their reliability and availability.
5. The subsystem automatic restart feature associated with the executive monitor equipment should be examined to determine if the number of manual interventions could be decreased by extending the executive monitor cycle time.

APPENDIX A

AZIMUTH SUBSYSTEM PERFORMANCE HISTORY

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FAILURES LISTING

1. Radio Frequency Switch One Assembly.

The Radio Frequency Switch One Assembly (RF SW-1) (Bendix part number 404-2592-0702) is used in all Bendix Microwave Landing Systems (MLS's). All of these units were manufactured and repaired by the Sanders Company, and they are referred to by batch number and serial number. A batch number is assigned to a number of units either manufactured or repaired at the same time.

The initial (first) batch was comprised of RF SW-1 production serial numbers 1 through 6 which were installed in the following prototype Bendix MLS's (one each in the azimuth and elevation subsystems):

- Basic Narrow
- Basic Wide
- Small Community

The second batch consisted of production units serial numbers 7 through 12 which were spare units for the first batch units. Batch two units were produced to the same specifications as those of the first batch, but the RF diodes (microfilm) were purchased from a different manufacturer. The third batch was comprised of failed units from batches one and two (serial numbers 0001, 0006, 008, and 011). When batch three units were repaired, Bendix Company personnel believe that the RF diodes of the original manufacturer were reincorporated in the batch three units. A fourth batch of units exists at the Bendix Company (Towson, Md.), consisting of batch one, two, and three units (serial numbers 0001 and 012), where they are in the failed state awaiting repair. One additional Sanders Company RF SW-1 assembly was utilized in this test period and is a feasibility model unit (Bendix part number 404-2585-0702). This unit was only utilized when a production unit was unavailable for replacement of a failed unit at the site. The feasibility unit's RF pin diodes do not meet the production units' isolation specification. Also, it is designed to operate from a 15-volt power supply; the production unit was designed to operate from a 40-volt power supply. A simple voltage dropping resistor circuit was utilized to accommodate this feasibility unit in the MLS subsystem and it typically produced low output transmission power.

The second batch units typically lasted about 10 days after installation according to Bendix Company personnel. Serial number 008 was taken apart at Bendix Company (Towson, Md.) on March 31, 1983; some RF diodes were found shorted closed and their driving resistors were found burned open. The RF diodes probably went bad first. There is speculation that the failure might have been induced by power failure. Any J-port circuit of the RF SW-1 assembly could be the failed port since no control information was kept in the logs on this aspect of the failed units. The particular J-port that failed varied with the installation.

a. RF SW-1 Assembly Failure History.

(1) On July 29, 1983, a third batch RF SW-1 assembly unit (S/N 0006) was received from Bendix Company and installed at DCA. This unit is still operating properly.

(2) From April 15 to July 29, 1983, the feasibility unit RF SW-1 assembly was utilized in the azimuth subsystem maintaining the transmission mode of operation.

(3) From April 6 to April 13, 1983, a second batch RF SW-1 assembly unit (S/N 011) was utilized (its original field site location was Wallops Island, Va.). On April 13, 1983, the site experienced an a.c. power interruption.

(4) From March 25 to April 6, 1983, the feasibility RF SW-1 assembly unit was utilized due to the unavailability of any other unit.

(5) From March 15 to March 25, 1983, a second batch RF SW-1 assembly S/N 008 was utilized (received from Bendix Company). On March 25, 1983, this unit failed after the site a.c. power was turned off to install new breakers for that site's a.c. power. When the a.c. site power was restored, that RF switching assembly unit (S/N 008) was found failed.

(6) On March 14, 1983, the azimuth subsystem experienced an intermittent power supply level being applied at TB-2 (in the beam antenna enclosure) that supplied the first batch RF SW-1 assembly unit (S/N 0001) which failed. Later, on the same day, first batch RF SW-1 assembly site spare unit (S/N 0006) was installed and it too failed. On March 15, 1983, the TB-2 intermittency was discovered. A TB-1 and TB-2 are collocated with each having screw terminations. These terminal board connections are mounted next to a blower fan which was installed as a modification to the beam antenna enclosure after it was installed at DCA. This fan's vibration is believed to have loosen the terminal board screw which connects the 40-volt power supply to the RF SW-1 assembly. The intermittent power situation first seemed like beam accuracy and beam ERP executive faults (as shown on the Russtrak recorder), and then ident signal problems (happening as early as March 7, 1983). The chargeable failure in this case is the loosened TB-2 connection that was a result of the beam antenna enclosure modification.

2. Scan Modulator Assembly.

a. The scan modulator assembly Bendix Company model number is 473-1; part number 404-0618-0701. It is a self-contained unit.

b. The monitor detection circuit senses for failures and has an output balanced line driven by a Fairchild 9614 line driver. Failure indications arise when any one of three conditions exist:

- (1) If a command is not executed.
- (2) If the assembly has not reached its operating temperature.
- (3) If this assembly's temperature exceeds its operating range.

c. Scan Modulator Assembly Failure History.

(1) On April 26, 1983, the scan modulator assembly unit S/N 04 was removed and unit S/N 05 was installed. Unit S/N 04 was yielding heater circuit failure executive fault signals, however, it was operating. An intermittent temperature detection circuit problem yielding executive faults existed, and by installing another unit (S/N 05), they were eliminated. The assembly unit S/N 04 was sent to the Bendix Company where it was disassembled. The scan modulator circuit and the heater circuit were found to be operating properly, but the temperature detection circuit was found to be intermittent, i.e., its thermocouple sensor-detection circuit was not operating properly all the time.

(2) On February 28, 1983, there was a scan modulator executive fault which was bypassed off in the maintenance monitor drawer by adding a jumper wire on the A-3 board from its terminal pin "B-12" to ground. Four hours later, the jumper wire was removed and the subsystem operated normally.

(3) On February 8, 1983, there was a scan modulator executive fault which was overcome by a manual toggle of the subsystem's restart switch that enabled it back into normal operation.

(4) On December 13, 1982, the first of the persisting scan modulator assembly executive faults occurred which was bypassed as explained in 2c(2) above so that the azimuth subsystem's guidance signal transmission would not be shutdown.

(5) On November 13, 1981, there was a scan modulator executive fault (refer to 2c(3) above).

(6) On May 4 and 5, 1981, there was one scan modulator executive fault which was bypassed as explained in 2c(2). Then, momentarily, the manual toggle switch was operated to restart the subsystem into normal operation.

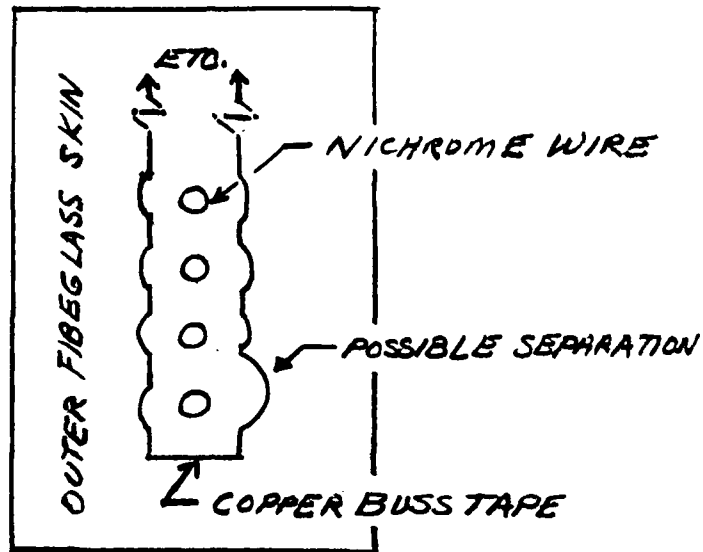
3. Beam Antenna Radome.

a. The front face of the beam antenna is a radome made up in a sandwich form of fiberglass reinforced polyester. The sandwich consists of two fiberglass reinforced skins over a honeycomb core and is approximately 0.58 inches thick. The honeycomb material is comprised of fiberglass and epoxy resin. Heating (deicing) is enabled with dissipative wire grids embedded in the front or outer skin. The wire grids consist of two copper buss tape layers enclosing nichrome heating wires (as shown in figure A-1). Primary power for the deicing circuit is controlled by a circuit breaker switch (S17).

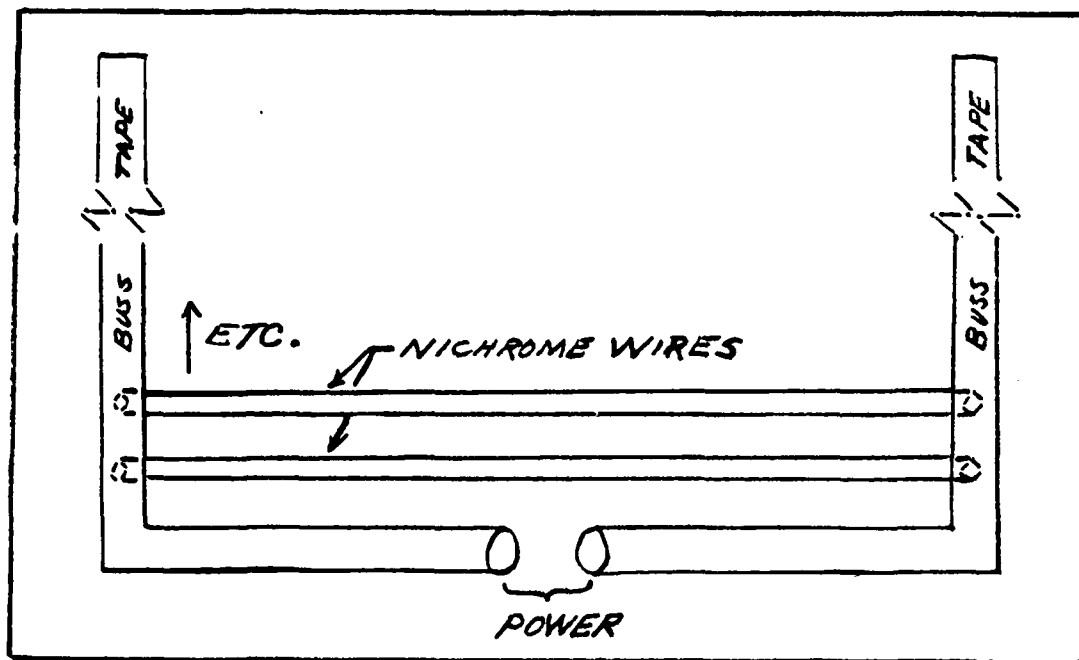
b. Radome Failure History.

(1) On March 3, 1983, the burned material of the beam antenna radome was removed, refilled with foam, and taped over.

(2) On February 25, 1983, the site person investigated the burned radome area and determined that the two copper buss tape layers holding the nichrome heating wires in the damaged radome area were separated causing an arcing between the nichrome wire and copper buss tape.

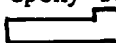


END VIEW - OUTER RADOME SKIN



RADOME SIDE VIEW

FIGURE A-1. BEAM ANTENNA RADOME'S OUTER FIBERGLASS SKIN

(3) On February 24, 1983, a flaming fire developed in the beam antenna's radome. The honeycomb's epoxy resin burned. The damaged area of the radome was in the following shape: . During the fire, the power was removed from this radome's heater circuit. After the fire was extinguished, the site person removed power from similar deicing circuits in the other MLS antenna.

c. Bendix Company personnel believe the separation of the buss tape was a manufacturing defect. Two possible solutions are as follows:

(1) Utilize a wider, higher current carrying copper tape; and/or

(2) Employ a thermostat controlled temperature in the radome to reduce the possible flexing of the radome.

4. 15-Volt Power Supply.

a. Failure History.

(1) On November 25, 1981, the 15-volt power supply located in the electronics rack power supply drawer was replaced with a spare unit due to a "high" ripple on its output. One or both of the output capacitors were bad. The bad unit was sent to Bendix Company where both output capacitors were found to be bad and were replaced. The repaired unit was returned to the azimuth site.

5. RF Connector.

a. Failure History.

(1) On October 20, 1981, J-4 RF connector was found loosened at its connection at the rear of the electronics rack RF unit drawer. The J-4 RF plug connection was tightened which eliminated any further preamble executive faults from occurring. This connection probably worked loose as the drawer was frequently opened and closed (not related to maintenance work).

6. Light Emitting Diode (LED).

a. This LED solid-state device has Bendix Company part number 404-2949-0701.

b. Failure History.

(1) On June 9, 1981, the maintenance monitor drawer assembly had one LED which was dim on lighting to show an executive fault. It was replaced on the same day from the spares supply with the same manufacturer's unit.

7. Air Conditioner System.

a. Failure History.

(1) On August 31, 1981, a new replacement Frederick Company air conditioner was installed in the beam antenna enclosure.

(2) On July 17, 1981, the failing air conditioner in the beam antenna enclosure was recharged with freon, but the air conditioner's cooling ability did not improve. The compressor was believed to have failed.

(3) On July 14, 1981, the failing beam antenna enclosure air conditioner was removed from its installation.

(4) On June 23, 1981, the beam antenna enclosure air conditioner was found to lose its cooling effectiveness at about 90° F (32.2° C).

(5) On June 21, 1981, the azimuth shelter's air conditioner thermostat had a loose wire at its connection due to the unit's vibration. This connection was tightened and, thereafter, the air conditioner operated properly. Lock washer usage on nearby wire connections is suggested.

(6) On June 14, 1981, the air conditioner in the azimuth shelter was found to have a leaking seal at its enclosure interface. RTV was applied, thereby, eliminating the leaks. When an MLS is installed, it is suggested that a thorough check of this seal be made around the enclosure's air conditioner.

ENVIRONMENTAL PROBLEMS

1. Power Outages.

a. Generalizations: The Basic Narrow MLS azimuth subsystem automatically attempts to restart itself upon restoration of site power following a power outage. If successful, the subsystem will be restarted with stabilized temperature and signals in approximately 32 minutes. In general, the power outage duration is not recorded due to the limitations of the MLS subsystem and its data collection instrumentation equipment. A 0.6-hour executive fault displacement in the two Russtrak recorder parameters shows the subsystem's automatic restart and stabilization time.

The beam ERP parameter trace on the Russtrak recorder is an output from a sample-hold detection circuit in the maintenance monitor assembly drawer. The parameter's restart and stabilization period are shown by the circuit's capacitor-like rise time output with a final "kick-in" when the subsystem has been on approximately 32 minutes.

b. In table A-1 the power outages occurrences part of the day are defined as follows:

Morning:	a.m. portion of the site person's workday.
Afternoon:	p.m. portion of the site person's workday.
Evening:	1630-2400 portion of the day.
Nite:	Portion of the day outside of workday.
Day:	a.m. and p.m. portion of workday.
All:	0000-2400 inclusive.

TABLE A-1. POWER OUTAGE LISTING

Date	Power Outage Time (Hours)	Start of Occurrence		Azimuth Subsystem Restarting Method	Remarks
		Start of Occurrence Time of Week	Per. of Day		
		Weekday	Weekend	Automatic	Manual
5/3/83	Glitch to 1 hour	X		X	
3/25/83	Uncertain	X			X
3/21-24/83	2 days, 16 hours	X			X
2/22/83	Glitch to 1 hour	X		X	
1/8/83	2-3 hours	X		X	
12/22/82	1-2 hours	X		X	
12/18-20/82	10-11 hours		X		X
10/21/82					
to 12/10/82	1 month, 20 days	X			X
10/20/82	3 glitches to 1 hour	X		X	
9/27/82	0.75 hours	X			X
8/22/82	4 glitches to 1 hour		X		
6/16/82	Glitch to 1 hour	X		X	
5/19/82	Glitch to 1 hour	X		X	
4/18/82	Glitch to 1 hour	X		X	
1/5/82	Glitch to 1 hour	X		X	

Powerline breakers replaced
(site)

Powerline cable replaced (site)

In executive fault additional 16
hours with power on
100-foot site powerline rein-
stalledEach outage automatically re-
startedAirport lost 1 phase of power
(to emergency power)Each outage automatically
restarted

TABLE A-1. POWER OUTAGE LISTING (CONTINUED)

Date	Power Outage Time (Hours)	Start of Occurrence		Start of Occurrence Time of Week	Per. of Day Morning Afternoon Evening Night	Azimuth Subsystem Restarting Method		Remarks
		Weekday	Weekend			Automatic	Manual	
11/24/81	Glitch to 1 hour	X			Night		X	In executive fault till restarted in morning
9/19/81	2-3 hour		X		Night	X		
8/1/81	8-9 hours	X			Day		X	
6/22/81	Glitch to 1 hour		X		Night	X		
6/18/81	2-3 hours	X			Evening	X		
5/28/81	Glitch to 1 hour	X			Evening	X		A second glitch occurred during restart
4/10/81	Glitch	X			Night	X		Glitch duration less than TWT hysteresis curve Less than full cycle restart
3/27/81	Uncertain		X		Day	X		A second glitch of occurred near end of first cycle time
3/26/81	Uncertain	X			Night	X		Same as 3/27/81, second glitch Near start of 1st restart cycle
3/23/81	Uncertain	X			Day	X		Same as 3/26/81
2/25/81	1-2 hours	X			Day	X		Same as 3/26/81

The power outages occurrences' day-of-the-week are defined as follows:

Weekday:	Monday	0730-2400
	Tuesday	0000-2400
	Wednesday	0000-2400
	Thursday	0000-2400
	Friday	0000-1630
Weekend:	Friday	1630-2400
	Saturday	0000-2400
	Sunday	0000-2400
	Monday	0000-0730

With reference to table A-1: During the three power outages of March 23, 26, 27, 1981, about 8 hours of azimuth subsystem operating time was lost. As a result of the long recording time between site data recorded dates/time, the time between each power outage cannot be determined from the logs. The site person was on vacation.

c. The power outages duration at the sites due to power system operational anomalies, commercial power cutoff, or airport power system checks usually lasted as shown in table A-2.

2. Weather Outages.

a. History.

(1) On June 30, 1980, the azimuth subsystem beam antenna radome's top coating of silibond 1828-4A was almost completely deteriorated by rain and snow. More and more, the beam ERP and beam accuracy parameters' performance was affected by the precipitation as observed by the monitor levels on the Russtrak recorders.

(2) By early 1981, daily rainfall of as little as 0.3 inches would cause beam accuracy deflections, all of which resulted in subsystem executive faults. This condition further deteriorated to 0.2 inches of daily rainfall doing the same thing.

(3) On September 9, 1981, the radomes' coverage coatings were stripped from the beam and monitor pole antennas, which resulted in a decreased beading of water on them. The beam accuracy parameter had a 0.04° deflection for a 0.18 inches daily precipitation.

(4) On October 12, 1981, all the azimuth subsystem antennas' radomes were stripped of their coatings with a teflon film being attached only to the beam and monitor pole antennas' radomes. Immediate and good effects were experienced by the beam accuracy parameter such as a daily precipitation of 0.84 inches that caused only a 0.02° deflection in the monitored parameter on the Russtrak recordings. Even ice pellets, snow in the air, and snow on the ground did not cause significant deflection of the beam accuracy parameter. A 1.56-inch daily rainfall only deflected the beam parameter by 0.04° .

TABLE A-2. SITE POWER OUTAGES ACCORDING TO OUTAGES' DURATION

	Glitch to 1 Hour	1-2 Hours	2-3 Hours	Greater Than 3 Hours
Subtotal:	22	2	6	2
<hr/>				
TOTAL: 32				
<hr/>				
% of Total:	68.75	6.25	18.75	6.25

(5) During February, 1983, the good beam accuracy parameter weather related experience, lasting from October 12, 1981, was marred by the two snow storms on February 6 and 11. The first snow fall had a maximum of 4.4 inches of laying snow that turned to glaze on February 7. An executive fault occurred on February 6 at 2330 that was overcome on February 7 at 0735 by manual restart. The second snowfall had a maximum of 16.4 inches of laying snow on February 11 which probably caused an executive fault. Other executive faults in February were explainable by chargeable failures in the azimuth subsystem.

(6) In the remaining reporting time through June 30, 1983, the azimuth subsystem was in executive fault by use of the feasibility model RF SW-1 assembly and the beam accuracy parameter was, consequently, not a reliable parameter to show subsystem executive fault status.

ENGINEERING CHANGES

1. Hydrophobic Radome Coatings.

a. History.

(1) For a history of the antennas radomes hydrophobic surface coatings, read Related Documentation, Reliability and Maintainability, item 4, section 2.5.1.1, Basic Narrow MLS and its related tables 2-8, 2-9, and 2-10.

2. Beam Accuracy Parameter Limits.

a. History.

(1) On June 17, 1982, the maintenance monitor drawer's A-5 board that had been modified by Bendix Company (Towson, Md.) was installed replacing the existing A-5 board in the azimuth subsystem. The new A-5 board contained a prom modification that changes the beam accuracy parameter's executive fault

limits from $\pm 0.13^\circ$ to $\pm 0.072^\circ$ which are displayed on the subsystem's RMMS cathode ray tube display. This was accomplished at the FAA's request to satisfy ICAO requirements. The Technical Center's RMMS data collection beam accuracy parameters executive fault limits of $\pm 0.13^\circ$ were not altered by this equipment change.

(2) On September 3, 1981, the maintenance monitor drawers BCC comparator board was reprogrammed with the new ICAO beam accuracy parameter executive fault limit specifications. This change did not alter that parameter's RMMS CRT displayed limits for the Technical Center's RMMS data set corresponding parameter limits.

2. Safety Warning Lamps/Bulbs.

a. Numbers of Bulbs/Lamps in Subsystem.

Refer to table A-3.

TABLE A-3. NUMBER OF WARNING LAMPS/BULBS IN THE AZIMUTH SUBSYSTEM

<u>Enclosure</u>	<u>Number of Lamps</u>	<u>Number of Bulbs</u>
Shelter	1	2
Beam Antenna	2	4
Monitor Pole	<u>1</u>	<u>2</u>
TOTAL	4	8

Note: The Norelco bulbs had imprinted on their glass "Heavy Duty Traffic" while the original bulbs has no indication of being useful for an extended lifetime.

b. History.

(1) On September 21, 1981, the monitor pole's air safety warning lamp bulb burned out and it was replaced with a Norelco bulb.

(2) On June 25, 1981, at least two air safety site warning bulbs were replaced with Norelco bulbs. The site locations of these bulbs were not recorded in the logs.

(3) On May 2, 1981, a beam antenna enclosure air safety warning bulb was replaced with a Norelco bulb.

(4) On April 30, 1981, one site air safety warning bulb was replaced with a Norelco bulb. The site location of this bulb is not recorded in the logs.

APPENDIX B

ELEVATION SUBSYSTEM PERFORMANCE HISTORY

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FAILURES LISTING

1. Data Link Signal Line Noise.

a. History.

About March 30, 1981, a Runway Visual Range System (RVR) was installed on this subsystem's runway. It was tied into the airport cable (100 pair) which was carrying the azimuth (AZ) sync signal. Cross talk noise from the RVR signals was picked up on the Az sync signal. From March 31 to April 1, 1981, airport personnel switched the Az sync signal to another cable pair in the 100 pair airport cable. The AZ sync signal then operated satisfactorily.

2. Maintenance Monitor CRT Display Power Supply.

a. Failures History.

(1) On March 7, 1983, the cathode ray tube (CRT) display had vertical roll on it. By test equipment display, a voltage (peak to peak) ripple of 2 volts was observed on the output side of capacitor C-44 in the maintenance monitor CRT display power supply. An on-hand nonfitting, electrically compatible capacitor was temporarily used to keep the CRT display working. An exact replacement capacitor was obtained through the contractor's project office and installed early April 1983.

(2) On February 9, 1981, the CRT display had a vertical roll on it. transistor U-14 in the vertical oscillator circuit was determined to be heat sensitive, but there was no spare transistor at the site. An exact replacement was obtained through the contractor's project office and installed about 2 weeks after the failure.

3. Air Conditioner System.

a. Failure History.

(1) In June 1983, the site person reinstalled the repaired Frederick air conditioner in the elevation subsystem's shelter. The air conditioner had just been repaired and had a new compressor.

(2) In early September 1982, the contractor's project office purchased a new compressor for the shelter's air conditioner. It was given to an outside party to repair in September 1982.

(3) On August 10, 1982, the site person could not start the shelter's air conditioner compressor and notified his company project office.

(4) On August 9, 1982, a new fan motor was delivered and installed in the shelter air conditioner on the same day by the site person.

(5) On July 19, 1982, a new fan motor was ordered through the contractor's project office.

(6) On July 14, 1982, the site person removed the shelter's air conditioner from its installed position and started disassembling the fan motor from it.

(7) From July 12 to 13, 1982, the elevation subsystem's shelter air conditioner (Frederick Co.) fan motor failed. The site person believes the motor's bearings wore out and jammed, causing a power circuit breaker to open. The shelter's emergency exhaust fan was turned on and was adequate for normal subsystem operation.

(8) On February 23, 1981, the site person applied RTV sealant to the shelter's air conditioner's housing and shelter junction where water leaks were observed.

4. Site, Trenched a.c. Power Cable.

a. Failure History.

(1) On January 5, 1982, the elevation subsystem's trenched a.c. power cable was severed by a construction trencher which was going in the wrong direction while putting in cables for an RVR installation near the site.

(2) From January 6 to 7, 1982, the airport electricians spliced the severed a.c. power cable together.

5. Waveguide.

a. Failure History.

(1) On January 7, 1982, the elevation subsystem power was turned on again, but the beam antenna did not receive any radio frequency (RF) energy. The waveguide from the shelter to the beam antenna was found to be damaged at the site of the severed and spliced site a.c. power cable and presumably occurred when the site's a.c. power cable was spliced together. The a.c. power cable and waveguide trenches are parallel and separated by 3 feet of earth.

(2) On January 8, 1982, it was determined that the waveguide had lost 0.5 pounds per square inch (psi) of its 2 psi of normal nitrogen gas pressure.

(3) On January 11, 1982, there was still no RF energy to the beam antenna.

(4) On January 12, 1982, there was still no RF energy to the beam antenna so the elevation subsystem was turned off. It remained depowered through January 21, 1982.

(5) On January 21, 1982, the filled hole at the site a.c. power cable splice was redug by the site person. The waveguide was found to have a large dent and bend which could have been made by a pick. The waveguide was not punctured according to the naked eye, and the site person attempted to straighten out the bend in this waveguide, but was only partially successful.

He measured the waveguide's electrical characteristics:

8 decibel (dB) low, Voltage Standard Wave Ratio (VSWR) was increased
Polarization changed
Beam accuracy parameter shifted
Differential Phase Shift Keying (DPSK) shifted.

The elevation subsystem site a.c. power was turned on, but the site was placed in a nontransmitting "test" mode. He refilled the hole in the ground.

(6) Between January 21 and May 6, 1982, the elevation subsystem remained in the "test" mode. The site person continued trying to eliminate the waveguide gas pressure leaks (many times) by purging the waveguide nitrogen gas to 2 psi. He cut out the damaged section of the waveguide and spliced in a new piece of waveguide using waveguide connectors. The entire new section and its "splices" were encased in fiberglass. The water table was high enough that water seeped into the hole region. Also, rain got into the splices. From March 17 to May 6, 1982, the hole remained unfilled.

(7) On May 6, 1982, the site person thought the waveguide had been purged successfully. He determined the waveguide loss was then 8.5 dB low which was probably due to the waveguide splices. The elevation subsystem was turned on and transmitting.

(8) From May 6 to 18, 1982, the elevation subsystem operated normally with only a slight drop in nitrogen gas pressure. On May 18, 1982, the ground hole was refilled.

(9) On May 19, 1982, a trench for a new waveguide was completed and a new waveguide was placed and secured in the trench. The waveguide was pressurized with nitrogen gas to 2 psi. The new installation could not be completed because more grounding wire was needed. The elevation subsystem remained transmitting with the original waveguide.

(10) On May 20, 1982, as a result of the previous nights rain storm, an executive fault was cleared in the morning by a toggle of the manual restart switch. Rain had beaded on the beam antenna's radome.

(11) On May 21, 1982, as on May 20, 1982, the weather was rainy and the executive fault status could not be cleared. Rain water had seeped into the original waveguide.

(12) On May 24, 1982, the new waveguide was electrically tied into the elevation subsystem and the original wave guide was disconnected.

(13) On May 25, 1982, the new waveguide's mounting brackets were installed.

(14) On May 26, 1982, the new waveguide was shortened to match the impedance of its connecting hardline. The line adapters were tightened and the new waveguides nitrogen gas was purged.

(15) On May 27, 1982, the site person refilled the a.c. power cable trench and secured the new waveguide in its own trench.

(16) On June 1, 1982, the rain from the previous night was found to have caused settling dips in the a.c. power cable trench fill. Additional earth was added to the dips to properly grade the trench. The new waveguide was resecured in its trench.

6. Waveguide Connector.

a. Generalization.

An airport practice is to cut the field grass near airport electronic facilities using field mowers with the mower operator contacting the field tower prior to working around field facilities. The operator may not pay adequate attention to avoid mower contact with the field facilities since most of the time the mowing is in the open field area of the airport. On May 22, 1981, the Basic Narrow Microwave Landing System (MLS) elevation subsystem waveguide connector was damaged during mowing.

b. Failure History.

On May 22, 1981, a mower was cutting the grass in close proximity to the antenna pad and it damaged the waveguide connector on the hardline cable. The site person immediately replaced the damaged waveguide connector with parts from his spares supply.

7. RF Connector.

a. Failure History.

On February 12, 1981, the "input" RF cable's connector (cable from the Communications Terminal Block) was found loose. The site person tightened it and the RF leakage decreased significantly.

ENVIRONMENTAL PROBLEMS

POWER OUTAGES.

1. Refer to table B-1 for a history listing of the elevation subsystem power outages due to power system anomalies, commercial power cutoff, or airport emergency power system checks.
2. Refer to tables A-1 and A-2 (appendix A) in the azimuth subsystem power outages section of this report. Also, please read the related expository to appreciate examples of power outage duration at DCA airport.

WEATHER OUTAGES.

1. Refer to table B-2 for the elevation subsystem weather outages listing.

TABLE B-1. POWER OUTAGE LISTING

Date	Power Outage Approx Start Time	Occurrence Start		Elevation Subsystem Method of Restart		Remarks
		Weekday	Weekend	Auto	Manual	
4/12/83	0100	X		X		Azimuth subsystem not affected by this power outage
4/10/83	1600		X	X		Same as 4/12/83
3/30/83	1100	X			X	Azimuth and elevation subsystems both affected by this power outage. Azimuth subsystem automatically restarted while the elevation subsystem remained in executive fault.
5/29/82	0230		X	X		Azimuth subsystem not affected by this power outage
6/21/81	1000		X		X	Azimuth and elevation subsystems both affected by this power outage. Azimuth subsystem automatically restarted while the elevation subsystem remained in executive fault.
5/28/81	1730	X			X	Same as 6/21/81
5/26/81	0900	X		X		Azimuth subsystem not affected by this power outage
5/2/81	0700		X	X		Same as 5/26/81
5/1/81	1300	X		X		Same as 5/26/81
2/25/81	1415	X		X		Same as 5/26/81
2/4/81	1800	X		X		Same as 5/26/81. Elevation subsystem experienced four momentary power outages over a 1-hour period. There was one momentary power outage 4 hours prior to that period.

TABLE B-2. WEATHER OUTAGES LISTING

Executive Fault			Occurrence		Elevation Subsystem Method of Restart	Remarks
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	
6/28/83	2130	6/28/83	2200	X	Auto X	About 1.55 inches of rain fell in the previous 2 hours.
6/28/83	2030	6/28/83	2035	X	X	About 0.76 inches of rain fell in the previous 3 hours.
2/11/83	1500	2/14/83	1245	X	X	About 16.4 inches of snow fell and accumulated on the ground throughout the day. Four inches on the ground at 0700. A blowing snowstorm.
2/6/83	2300	2/7/83	0820	X	X	About 4.4 inches of snow lay on the ground by 2300 February 6. By 0700 on February 7, there was 4.0 inches on the ground. A glazed surface developed.
2/6/83	2245	2/6/83	2246	X	X	Same as 2/6/83 2300.
12/26/82	0400	12/28/82	0815	X	X	About 0.02 inches of rain fell in the previous 1 hour.
12/16/82	0815	12/16/82	0830	X	X	About 0.69 inches of rain fell throughout the previous night.
10/16/82	1000	10/18/82	0745	X	X	About 0.04 inches of rain fell the morning of 10/16/82.
9/22/82	0115	9/22/82	0745	X	X	About 0.95 inches of rain fell throughout the night and morning. Executive faults were momentary and on-going from 0115 to 0315 during which time 0.17 inches of rain fell. By 0400 another 0.30 inches of rain fell and the subsystem went into steady executive fault.

TABLE B-2. WEATHER OUTAGES LISTING (CONTINUED)

Executive Fault			Occurrence Start		Elevation Subsystem Method of Restart		Remarks	
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	Auto		Manual
9/20/82	0745	9/20/82	0845	X		X		About 0.19 inches of rain fell throughout the night until 0745 when several momentary executive faults occurred.
8/17/82	1845	8/18/82	0745	X			X	About 0.66 inches of rain fell throughout the night of 8/17/82.
8/11/82	2000	8/11/82	2400	X		X		About 0.02 inches of rain fell the evening of 8/11/82. There were 5 momentary executive faults.
8/9/82	1500	8/9/82	1600	X			X	About 0.84 inches of rain fell in the previous 2 hours.
8/5/82	1900	8/6/82	0745	X			X	About 0.35 inches of rain fell the previous 1 hour.
8/2/82	1930	8/2/82	1935	X		X		About 0.10 inches of rain fell between 1900 and 2000.
7/30/82	0745	7/30/82	1645	X		X		About 1.51 inches of rain fell throughout the day. There were nine momentary executive faults during this period.
7/27/82	2015	7/28/82	0745	X			X	About 0.10 inches of rain fell in the previous 1 hour.
7/19/82	1845	7/20/82	0745	X			X	About 0.73 inches of rain fell in the previous 3 hours.
7/3/82	1400	7/6/82	0815		X		X	About 0.31 inches of rain fell during the day of 7/3/82.

TABLE B-2. WEATHER OUTAGES LISTING (CONTINUED)

Executive Fault				Occurrence		Elevation Subsystem Method of Restart		Remarks
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	Auto	Manual	
6/29/82	1615	6/30/82	0815	X			X	
6/10/82	1015	6/10/82	1200	X		X		About 0.26 inches of rain fell during the period and the previous 2 hours. Six momentary executive faults occurred during the period.
6/1/82	1730	6/1/82	1930	X		X		About 1.11 inches of rain fell in the previous 2 hours. Sixteen momentary executive faults occurred during the period.
5/29/82	0400	6/1/82	0810		X		X	About 1.24 inches of rain fell the night of 5/28/82 prior to the executive fault period.
5/22/82	1130	5/24/82	0930		X		X	About 1.13 inches of rain fell in the previous 3 hours. Rain water seeped into the original waveguide. Switched to the replacement waveguide to turn on the subsystem.
12/15/81	1700	12/16/81	0815	X			X	About 0.40 inches of ice pellets/snow had fallen and accumulated on the ground prior to the executive fault.
2/23/81	1500	2/24/81	0745	X			X	About 0.51 inches of rain fell the prior night and the day of the executive fault period. Rain beaded on the monitor pole antenna radome.
1/2/81	0800	1/20/81	0800	X			X	On 1/1-2/81 snow accumulated to 2 inches.

2. On October 27, 1981, lightning struck the azimuth sync signal line to the elevation subsystem causing a negative high voltage on the line resulting in the failure of the 55113 integrated circuit chip located in the remote control status monitor assembly. This chip was not protected against ground referenced, negative going high voltages (also ringing) in that circuitry. Subsequently, the elevation subsystem went into executive fault. The chip was replaced. Later, the subsystem was manually restarted by enabling the restart toggle switch. A redesigned circuitry replaced the 55113 circuitry at a much later date.

VEHICULAR INTERFERENCE.

A listing of the elevation subsystem's mower and truck environmental interference is shown in table B-3.

UNKNOWN CAUSES.

A listing of the elevation subsystem's executive faults due to unknown causes is shown in table B-4.

ENGINEERING CHANGES

1. Hydrophobic Radome Coatings.

a. History.

(1) For a history of the antennas radomes hydrophobic surface coatings read Related Documentation, reliability and maintainability, item 4, section 2.5.1.1, Basic Narrow MLS, and its related tables 2-8, 2-9, and 2-10.

2. Blade Monitor Pole Antenna.

a. History.

(1) On February 7, 1983, the blade antenna was placed next to the monitor pole horn antenna (remaining in place) at the same height. Snow was laying over the ground. The blade antenna's narrower beamwidth was effective in eliminating the spectral "point" reflected multipath which degraded the monitored signal.

(2) On October 19, 1981, the design of an eight-dipole element monitor pole antenna was tested. Its purpose was to decrease the beamwidth of the monitor pole antenna, which it did.

3. RMMS's Small Community Status Parameters.

a. History.

(1) On June 10, 1982, the site person removed the A5 board from the maintenance monitor drawer and shipped it to the contractor's project office where its prom program was to be modified.

TABLE B-3. MOWER/TRUCK VEHICULAR INTERFERENCE LISTING

Momentary Executive Faults										Elevation Subsystem Method of Restart	Interference Vehicle		Remarks
Date	Time of Day		Occurrence		No.	Duration Period		Auto			Mower	Truck	
	All Day	Afternoon	Week Day	Week End		Hours	Minutes	Auto	Manual				
6/9/83		X		X	7	0	36	X		X			
5/20/83		X		X	3	0	30	X		X			
5/10/83			X	X	5	1	36	X		X			
9/3/82		X		X	6	2	00	X		X			
8/13/82	X			X	8	8	00	X		X			
7/7/82		X		X	6	2	36	X		X			
6/11/82			X	X	4	1	00	X		X			
6/2/82			X	X	5	0	24	X		X			
5/19/82		X		X	3	0	24	X		X			
9/1/82	X			X	4	6	00	X		X			
8/25/81		X		X	1	0	05	X			X	Weed killer dispenser.	
7/29/81		X		X	4	0	36	X		X			
5/27/81		X		X	7	0	36	X		X			
5/15/81		X		X	5	1	12	X		X			
5/13/81			X	X	1	0	5	X			X		

TABLE B-4. EXECUTIVE FAULTS WITH NO KNOWN CAUSES LISTING

Executive Fault				Occurrence Start		Elevation Subsystem Method of Restart		Remarks
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	Auto	Manual	
2/19/83	1615	2/21/83	0815		X		X	A very large number of executive faults.
1/29/83	0945	1/29/83	1015		X	X		
1/28/83	1945	1/29/83	2015		X	X		
1/27/83	2030	1/27/83	2100	X		X		
9/2/82	1145	9/3/82	0745	X			X	

(2) On June 17, 1982, the site person received the modified A5 board from his project office reinstalled the board in the maintenance monitor drawer. The modification checked out satisfactorily.

4. Air Sync.

a. History.

(1) On August 5-6, 1981, the site person installed the air sync equipment and operated it. His main purpose was to check out the installation characteristics of this equipment. It was successfully installed and operated. As expected, some aircraft blocked the sync signal from time to time resulting in the elevation subsystem going into executive fault status. The air sync was not used during normal operation of the elevation subsystem.

(2) On September 1, 1981, the site person noticed the air sync light indicator in the elevation shelter was showing no air sync. Upon investigation he found the air sync antenna and pole attached to it had rotated in the pole clamps holding them to the shelter. He repositioned the antenna and tightened the clamp connections. The antenna/pole did not rotate again during the balance of the test period. The airport wind velocity was ruled out as a cause of pole rotation in that the maximum velocity between August 5 and September 1, 1981, was 14 miles per hour (mph). It is noted that many helicopters hover closely above the elevation subsystem shelter during the landing maneuvers and may have caused the antenna rotation.

5. Safety Warning Lamps/Bulbs.

a. Number of Bulbs/Lamps in Subsystem. Refer to table B-5.

TABLE B-5. NUMBER OF WARNING LAMPS/BULBS
IN THE ELEVATION SUBSYSTEM

<u>Enclosure</u>	<u>Number of Lamps</u>	<u>Number of Bulbs</u>
Shelter	1	2
Beam Antenna	1	2
Monitor Pole	<u>2</u>	<u>2</u>
Total	4	6

Note: The Norelco bulbs had imprinted on their glass "Heavy Duty Traffic" while the original bulbs had no indication of being useful for an extended lifetime.

b. Failure History.

On June 9, 1982, the shelter's air safety warning lamp bulbs were replaced with two Norelco bulbs.

AZIMUTH SUBSYSTEM SYNCHRONIZATION SIGNAL

1. Sync Signal Origin. The MLS configuration sync signal is developed within the azimuth subsystem's local control/status assembly and distributed to the subsystems via a land line. The line driver circuitry for this distribution is on the system synchronization printed circuit board "BBF" located in slot A3.
2. Sync Signal Use. The elevation subsystem by its design requires the presence of an azimuth subsystem sync signal to be in the guidance transmission mode of operation. The azimuth subsystem does not send a sync signal when it is not transmitting. When the sync signal is not received by the elevation subsystem, the subsystem is in executive fault. When the azimuth subsystem was not transmitting, the elevation subsystem sync signal sensing could be bypassed by removing the A3 board in its maintenance monitor assembly drawer. This precluded the executive fault action in the elevation subsystem. It also eliminated the possibility of executive fault action of the preamble, frequency, and timing parameters. Bypassing of the sync signal's presence was only to allow for the continuing collection of elevation subsystem performance data during an azimuth subsystem nontransmission.
3. Signal Loss History. The history of sync signal loss in this test period is shown in table B-6.

TABLE B-6. LOSS OF AZIMUTH SYNC SIGNAL

Executive Fault				Occurrence		Elevation Subsystem Method of Restart		Remarks
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	Auto	Manual	
6/17/83	1500	6/22/83	0900	X			X	Power outage at azimuth site.
6/14/83	1145	-	-	X		X		
5/15/83	1815	5/16/83	0915		X		X	
5/8/83	1815	5/9/83	0915		X		X	
5/3/83	0415	5/3/83	0915	X			X	Power outage at azimuth site. Azimuth subsystem automatically restarted. Elevation subsystem did not.
5/2/83	1115			X		X		Azimuth site low power input. The "severity" of the low power lasted less than 5 minutes. The elevation subsystem responded 1:1 with the azimuth executive fault. Low power at the azimuth site continued until the power outage of 5/3/83.
4/26/83	1300	4/28/83	1300	X		X		Azimuth subsystem had intermittent problem. Elevation subsystem intermittently responsive.
4/25/83	0945	4/25/83	1545	X			X	Azimuth Subsystem tests.
4/14/83	1045	4/14/83	1145	X			X	
4/13/83	0500	4/14/83	0800	X			X	Azimuth subsystem RF SW-1 assembly failure.
4/6/83	1415	-	-	X		X		Replaced RF SW-1 assembly in azimuth subsystem.

TABLE B-6. LOSS OF AZIMUTH SYNC SIGNAL (CONTINUED)

Executive Fault				Occurrence Start		Elevation Subsystem Method of Restart		Remarks
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	Auto	Manual	
3/29/83	0900	-	-	X		X		Azimuth site power problem.
3/21/83	0300	3/16/83	0815	X			X	
3/16/83	0100	3/16/83	0815	X			X	
3/4/83	1630	3/7/83	0830		X		X	
2/22/83	1015	2/23/83	1245	X			X	Azimuth site power outage. Azimuth subsystem automatically restarted. Elevation subsystem did not.
2/17/83	1015	2/17/83	1045	X			X	
2/8/83	1300	2/9/83	0820	X			X	Azimuth subsystem equipment failure.
2/7/83	0000	2/7/83	0820	X			X	
1/18/83	0515	1/18/83	0815	X		X		Sixteen momentary azimuth subsystem executive faults with the elevation subsystem responding 1:1.
1/8/83	1600	1/10/83	0815		X		X	
12/22/82	0430	12/22/82	0745	X			X	Azimuth site power outage. Azimuth subsystem automatically restarted. Elevation subsystem remained in executive fault.
12/20/82	0000	12/22/82	0815		X		X	
10/20/82	0800	12/13/82	0815	X			X	Azimuth site power problem.

TABLE B-6. LOSS OF AZIMUTH SYNC SIGNAL (CONTINUED)

Executive Fault				Occurrence		Elevation Subsystem Method of Restart		Remarks
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	Auto	Manual	
9/27/82	0100	9/27/82	0815	X			X	Azimuth site power problem.
8/21/82	0745	8/23/82	0745		X		X	Airport power outage: Azimuth subsystem automatically restarted. Elevation subsystem remained in executive fault.
6/16/82	2115	6/17/82	0815	X			X	Azimuth site power outage. Azimuth subsystem automatically restarted. Elevation subsystem remained in executive fault.
5/19/82	1615	5/20/82	0815	X			X	Azimuth site power outage. Azimuth subsystem automatically restarted. Elevation subsystem remained in executive fault.
11/23/81	1930	11/24/81	0815	X			X	Same as 5/19/82.
11/13/81	0145	11/13/81	0745	X			X	Azimuth subsystem equipment failure.
10/20/81	0600	10/20/81	0830	X		X		Numerous momentary azimuth subsystem preamble parameter executive faults.
10/13/81	1400	10/13/81	1600	X			X	Azimuth subsystem beam antenna radome recoated.
10/12/81	1400	10/12/81	1600	X			X	Azimuth subsystem beam antenna radome cleaned.
10/6/81	1935	10/7/81	0835	X			X	Azimuth subsystem monitor pole antenna radome beading with rain. 0.58 inches of rainfall in the previous hour.
9/19/81	0800	9/21/82	0805		X		X	Azimuth site power outage. Azimuth subsystem automatically restarted. Elevation subsystem remained in executive fault.

TABLE B-6. LOSS OF AZIMUTH SYNC SIGNAL (CONTINUED)

Executive Fault				Occurrence		Elevation Subsystem Method of Restart		Remarks
Start Date	Start Time	Stop Date	Stop Time	Weekday	Weekend	Auto	Manual	
9/14/81	1600	9/15/81	0810	X			X	Azimuth site power outage. Azimuth subsystem automatically restarted. Elevation subsystem remained in executive fault.
8/11/81	1930	-	-	X		X		Azimuth subsystem beam antenna radome affected by rain. Elevation system experienced 1 momentary beam accuracy parameter executive fault.
8/1/81	0730	-	-		X	X		Azimuth site momentary power outages.
6/18/81	1400	-	-	X		X		Azimuth site momentary power outage.
5/4/81	0315	5/4/81	0815	X			X	Azimuth subsystem equipment failure.
4/28/81	1730	-	-	X		X		Azimuth subsystem beam antenna radome affected momentarily by rain.
4/10/81	0630	-	-	X		X		Azimuth site power outage.
3/23/81	1530	3/26/81	0815	X			X	Subsystem automatically restarted. Elevation subsystem remained in executive fault.
2/11/81	1900	-	-	X			X	Azimuth subsystem beam antenna radome affected by rain. 0.18 inches of rain fell in the previous hour.

APPENDIX C
SAMPLES OF COLLECTED DATA

TABLE C-1. RMMS PARAMETERS' MONTHLY-PLOTS CHARACTERISTICS

Subsystem		Y-Axis				Y-Axis				Y-Axis			
		Function		Scale		Function	Scale		Exec. Fault Limits				
				Min.	Max.		Min.	Max.					
AZ	EL	Parameter	Days	Min.	Max.	Function	Min.	Max.	Min.	Max.			
X		Beam Accuracy	X	X	X	Degrees	-0.3	+0.3	-0.13*	+0.13*			
X		Beam ERP	X	X	X	Decibels	-4.0	+0.2	-3.0	-			
X		TWTA Power Output	X	X	X	Decibels	-4.0	+0.2	-2.0	-			
X		Antenna Temp.	X	X	X	Degree Centigrade	-40.0	+80.0	-10.0	+50.0			
	X	Beam Accuracy	X	X	X	Degrees	-0.15	+0.15	-0.071	+0.071			
	X	Beam ERP	X	X	X	Decibels	-4.0	+2.0	-3.0	-			
	X	TWTA Power Output	X	X	X	Decibels	-4.0	+2.0	-2.0	-			
	X	Antenna Temp.	X	X	X	Degree Centigrade	-40.0	+80.0	-10.0	+50.0			

Note: "X" means "Applies."

ND-A166 916

HARDWARE PERFORMANCE ANALYSIS OF THE BASIC NARROW
MICROWAVE LANDING SYSTE. (U) FEDERAL AVIATION
ADMINISTRATION TECHNICAL CENTER ATLANTIC CIT.

2/2

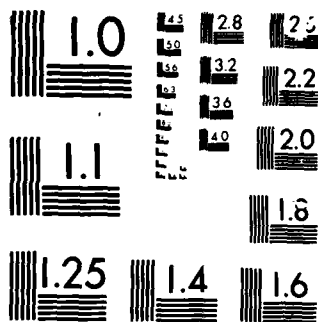
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MICROCOPY

CHART

F-2769191

FACILITY MAINTENANCE LOG			STATION WASHINGTON NATIONAL	MONTH AND YEAR MARCH, 1983	
			SUBJECT OF LOG MLS-314 A2		
DATE	TIME (24 HOURS)	CODE	REMARKS	INITIALS	
7	0730		SITE DOWN ON ARRIVAL - BEAM EOP. FOUND "FOO" BEAM TO BE $\frac{1}{3}$ THE AMPLITUDE OF "TO" BEAM. TROUBLE SHOOTING SYSTEM	JP	
8	0730		SITE DOWN ON ARRIVAL - LOW IDENT EOP. BEAMS NORMAL. RESTARTED SYSTEM AND OPERATION WAS NORMAL.	JP	
9	0730		SITE DOWN - LOW IDENT AND OCI EOP. BEAMS NORMAL. TROUBLE SHOOTING SYS.	JP	
10	0815		SITE DOWN - LOW BEAM EOP. IDENT/OCI'S NORMAL. TROUBLE SHOOTING PROBLEM.	JP	
11	0815		SITE DOWN - LOW POWER (BEAM, IDENT, OCI'S). TROUBLE SHOOTING PROBLEM.	JP	
14	0815		SITE DOWN - TWO DEFECTIVE RF SWITCHES (ORIGINAL SWITCH AND SPARE). NO REPLACEMENT.		
15	0815		SITE DOWN. INSTALLED NEW SWITCH (FROM TOWSON). FOUND PROBABLE CAUSE OF RF SWITCH FAILURES. TB2 IN BEAM ANTENNA ENCLOSURE WAS MOUNTED NEXT TO BLOWER FAN. VIBRATION OF BLOWER CAUSED THE TERMINAL SCREW		
DATE	SIGNATURE OF SECTOR MANAGER/DESIGNEE		DATE	SIGNATURE OF MAINTENANCE TECHNICIAN	
			15 MAR, 83	J. J. G. L. T. W.	

Form 6030-1 (10-70) FORMERLY FAA FORM 406C

U. S. GOVERNMENT PRINTING OFFICE: 1974-537-284

FIGURE C-1. AZIMUTH SUBSYSTEM FACILITY MAINTENANCE LOG

F- 5152173

FACILITY MAINTENANCE LOG

STATION

WASHINGTON NATIONAL

SUBJECT OF LOG

MIS - BILL EL

MONTH AND YEAR

OCT 1981

DATE	TIME (24 HOURS)	CODE	REMARKS	INITIALS
	1500		PERFORMED DAILY CHECKS AND RECORDED READINGS.	ST
9	0815		ARRIVED AT SITE. PERFORMED DAILY CHECKS AND RECORDED READINGS.	ST
	1130		PERFORMED DAILY AND WEEKLY CHECKS AND RECORDED READINGS.	ST
12	0815		ARRIVED AT SITE. PERFORMED DAILY CHECKS AND RECORDED READINGS.	ST
	1500		PERFORMED DAILY CHECKS AND RECORDED READINGS. CHECKED SYS. TO OBTAIN READINGS. AZ SITE DOWN - TILTA SHUT-OFF FOR RADOME CLEANING.	ST
13	0750		ARRIVED AT SITE. PERFORMED DAILY CHECKS AND RECORDED READINGS.	ST
	1500		STRIPPED IDELT/MPERCCF RADOME. CHECKED BEAM RADOME. PRUNED AND COATED BEAM, IDELT/CCF AND VIOLET (PINE) WINDOW. SITE SHUT DOWN FOR RADOME CLEANING. RESTARTED - PERFORMED DAILY CHECKS AND RECORDED READINGS.	ST
DATE	SIGNATURE OF SECTOR MANAGER, DESIGNEE		DATE	SIGNATURE OF MAINTENANCE TECHNICIAN
			13 OCT 81	ST

FAA Form 6030-1 (10-79) FORMERLY FAA FORM 408C

U.S. Government Printing Office 1977-774-913

FIGURE C-2. ELEVATION SUBSYSTEM FACILITY MAINTENANCE LOG

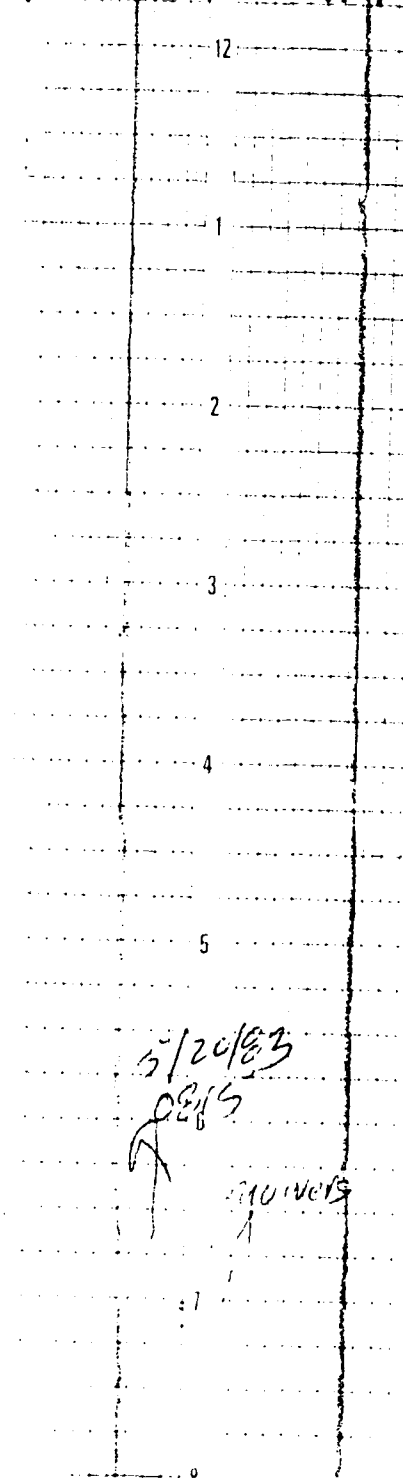
BASIC NARROW MLJ SYSTEM

ELEVATION SUBSYSTEM

BEAM ACC. BEAM ERP

-0.1° 0 +0.1° -148°

↑ ↑



AZIMUTH SUBSYSTEM

BEAM ACC. BEAM ERP

-0.1° 0 +0.1° -148°

↑ ↑

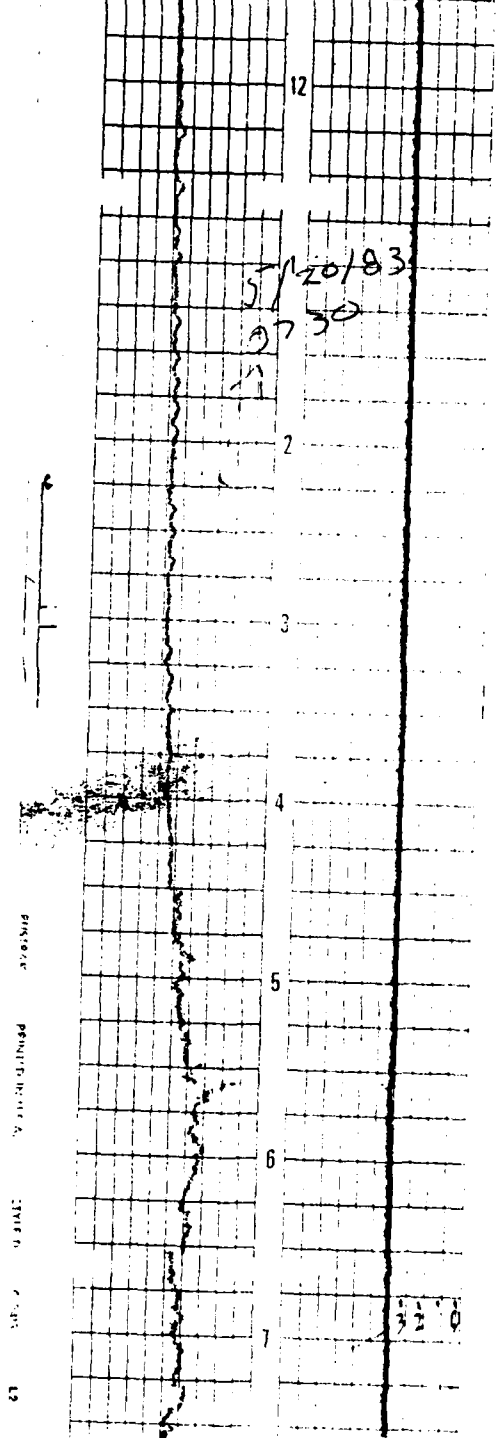


FIGURE C-3. AZIMUTH AND ELEVATION SUBSYSTEMS RUSSTRAK RECORDINGS

MLS TECHNICAL PERFORMANCE RECORD

Location (airport,city,state)				Frequency		Channel		Supervisor									
NATIONAL AIRPORT, WASHINGTON, D.C.				5060.7		99											
Facility		Runway		Equipment Configuration										Category		Coverage	
12		18		BASIC NARROW (BENDIX)										I		± 40	
Lat.	Beam Accur	Beam ERP	IDENT ERP	L SLS ERP	R SLS ERP	FREQ	TWT POWER	EXC POWER	ELECT TEMP	ANT TEMP	LAMPS L CON	LAMPS MON	Remarks	Init			
0-13	0-3dB	0-3dB	0-3dB	0-3dB	0-3dB	0-10K	0-2dB	0-2dB	25 C	25 C	ok	ok					
1																	
2																	
3	0730	-0.05	+1.8	0.0	-1.2	-1.2	+4	0.0	-1.5	+21	+15	✓	✓				
4	1545	-0.04	+1.8	-1.3	-1.3	-1.4	+4	0.0	-1.5	+24	+14	✓	✓				
5	0130	-0.05	+1.8	0.0	0.0	-1.2	+4	0.0	-1.5	+21	+15	✓	✓				
6	0230	-0.05	+1.8	0.0	-1.2	-1.2	+6	0.0	-1.5	+24	+14	✓	✓				
7	0745	-0.04	+1.8	0.0	-1.2	-1.2	+4	0.0	-1.5	+21	+15	✓	✓				
8	1545	-0.04	+1.8	-1.3	0.0	-1.3	+4	0.0	-1.5	+24	+14	✓	✓				
9	0130	-0.05	+1.8	0.0	-1.2	-1.2	+6	0.0	-1.5	+24	+14	✓	✓				
10	0745	-0.04	+1.8	-1.3	0.0	-1.3	+4	0.0	-1.5	+24	+14	✓	✓				
11	1545	-0.04	+1.8	-1.3	-1.2	-1.4	+4	0.0	-1.5	+21	+15	✓	✓				
12	0730	-0.05	+1.8	0.0	-1.2	-1.2	+4	0.0	-1.5	+21	+15	✓	✓				
13	1545	-0.04	+1.8	-1.3	0.0	-1.3	+4	0.0	-1.5	+24	+14	✓	✓				
14	0130	-0.05	+1.8	0.0	-1.2	-1.2	+6	0.0	-1.5	+24	+14	✓	✓				
15	0745	-0.04	+1.8	-1.3	-1.2	-1.4	+4	0.0	-1.5	+24	+14	✓	✓				
16	1545	-0.04	+1.8	-1.3	-1.2	-1.4	+4	0.0	-1.5	+24	+14	✓	✓				
17	0730	-0.05	+1.8	0.0	-1.2	-1.2	+4	0.0	-1.5	+21	+15	✓	✓				
18	1545	-0.04	+1.8	-1.3	0.0	-1.3	+4	0.0	-1.5	+24	+14	✓	✓				
19	0130	-0.05	+1.8	0.0	-1.2	-1.2	+6	0.0	-1.5	+24	+14	✓	✓				
20	0745	-0.04	+1.8	-1.3	-1.2	-1.4	+4	0.0	-1.5	+24	+14	✓	✓				
21	1545	-0.04	+1.8	-1.3	-1.2	-1.4	+4	0.0	-1.5	+24	+14	✓	✓				
22																	
23																	
24	0730	-0.04	+1.8	-1.2	0.0	-1.4	+4	0.0	-1.5	+20	+15	✓	✓				
25	1545	-0.04	+1.8	-1.2	0.0	-1.4	+4	0.0	-1.5	+23	+20	✓	✓				
26	0730	-0.05	+1.8	-1.2	0.0	-1.4	+4	0.0	-1.5	+21	+14	✓	✓				
27	1545	-0.04	+1.8	-1.2	-1.3	-1.4	+4	0.0	-1.5	+23	+14	✓	✓				
28	0730	-0.05	+1.8	-1.2	0.0	-1.4	+4	0.0	-1.5	+20	+14	✓	✓				
29	1545	-0.04	+1.8	-1.2	-1.3	-1.4	+4	0.0	-1.5	+23	+14	✓	✓				
30	0730	-0.05	+1.8	-1.2	0.0	-1.4	+4	0.0	-1.5	+20	+14	✓	✓				
31	1545	-0.04	+1.8	-1.2	-1.3	-1.4	+4	0.0	-1.5	+23	+14	✓	✓				

FIGURE C-4. AZIMUTH SUBSYSTEM TECHNICAL PERFORMANCE RECORD

MLS TECHNICAL PERFORMANCE RECORD

[illegible]

FIGURE C-5. ELEVATION SUBSYSTEM TECHNICAL PERFORMANCE RECORD

MLS PERFORMANCE CHECKLIST

Washington National Airport
Runway 18
Basic Narrow System

Date: Jan 14, 83

Azimuth Station ☒
Elevation Station ☐

Weekly ☒
Monthly ☐
Quarterly ☐
Semi-Annual ☐
Annual ☐

	ITEM	LIMITS	ACTUAL	GOOD	BAD	COMMENTS	IN
Weekly	Electronics +5V.	+4.75/ +5.25	+5.17	✓			
	Electronics +15V.	+14.30/+15.80	+15.00	✓			
	Electronics -15V.	-14.30/-15.80	-15.09	✓			
	Electronics +20V.	+19.00/+21.00	+19.45	✓			
	Antenna +5V.	+4.75/ +5.25	+5.04	✓			
	Antenna +24V.	+20.00/+28.00	+24.1	✓			
	Antenna -40V.	-35.00/-45.00	-40	✓			
	Monitor (1) +5V.	+4.75/ +5.25	+5.1	✓			
	Monitor (2) +5V.	+4.75/ +5.25	+5.11	✓			
	Monitor +15V.	+14.70/+15.30	+15.05	✓			
	Monitor -15V.	-14.70/-15.30	-15.01	✓			
	Restart			✓			
	Morse Code			✓			
	Remote Control			✓			
Mon	Radome Coating				✓		
	Beam Accuracy	per 4041035/36					
	ERP Limits	per 4041035/36					
	Sync Timing	per 4041036					
	Transmitter Power	per 4041035/36					
	Obstruction Lights						
Quarterly							
	Transmitter Freq.	per 6850.33					
	Ant Alignment						
Semi-Annual							
	Aux Data	per 6850.33					
	Basic Data	per 6850.33					
	10 MHz Oscillator	per 6850.33					
Annual							
	Vent Fan	per 6850.33					
	Cabinet Blower	per 6850.33					
	Fire Extinguishers						

FIGURE C-6. AZIMUTH SUBSYSTEM WEEKLY PERFORMANCE CHECKLIST

MLS PERFORMANCE CHECKLIST

Washington National Airport
Runway 18
Basic Narrow System

Date: JAN 14, 83

Azimuth Station ☐
Elevation Station ☒

Weekly ☒
Monthly ☐
Quarterly ☐
Semi-Annual ☐
Annual ☐

	ITEM	LIMITS	ACTUAL	GOOD	BAD	COMMENTS	IN
Weekly	Electronics +5V.	+4.75/ +5.25	+5.22	✓			
	Electronics +15V.	+14.30/+15.80	+15.3	✓			
	Electronics -15V.	-14.30/-15.80	-15.32	✓			
	Electronics +20V.	+19.00/+21.00	+20.1	✓			
	Antenna +5V.	+4.75/ +5.25	+5.01	✓			
	Antenna +24V.	+20.00/+28.00	+24	✓			
	Antenna -40V.	-35.00/-45.00	-40.1	✓			
	Monitor (1) +5V.	+4.75/ +5.25	+5.24	✓			
	Monitor (2) +5V.	+4.75/ +5.25	+5.15	✓			
	Monitor +15V.	+14.70/+15.30	+15.11	✓			
	Monitor -15V.	-14.70/-15.30	-15.09	✓			
	Restart			✓			
	Morse Code						
	Remote Control			✓			
	Radome Coating			✓			
Montl	Beam Accuracy	per 4041035/36					
	ERP Limits	per 4041035/36					
	Sync Timing	per 4041036					
	Transmitter Power	per 4041035/36					
	Obstruction Lights						
Quarterly							
	Transmitter Freq.	per 6850.33					
	Ant Alignment						
Semi-Annual							
	Aux Data	per 6850.33					
	Basic Data	per 6850.33					
	10 MHz Oscillator	per 6850.33					
Annual							
	Vent Fan	per 6850.33					
	Cabinet Blower	per 6850.33					
	Fire Extinguishers						

FIGURE C-7. ELEVATION SUBSYSTEM WEEKLY PERFORMANCE CHECKLIST

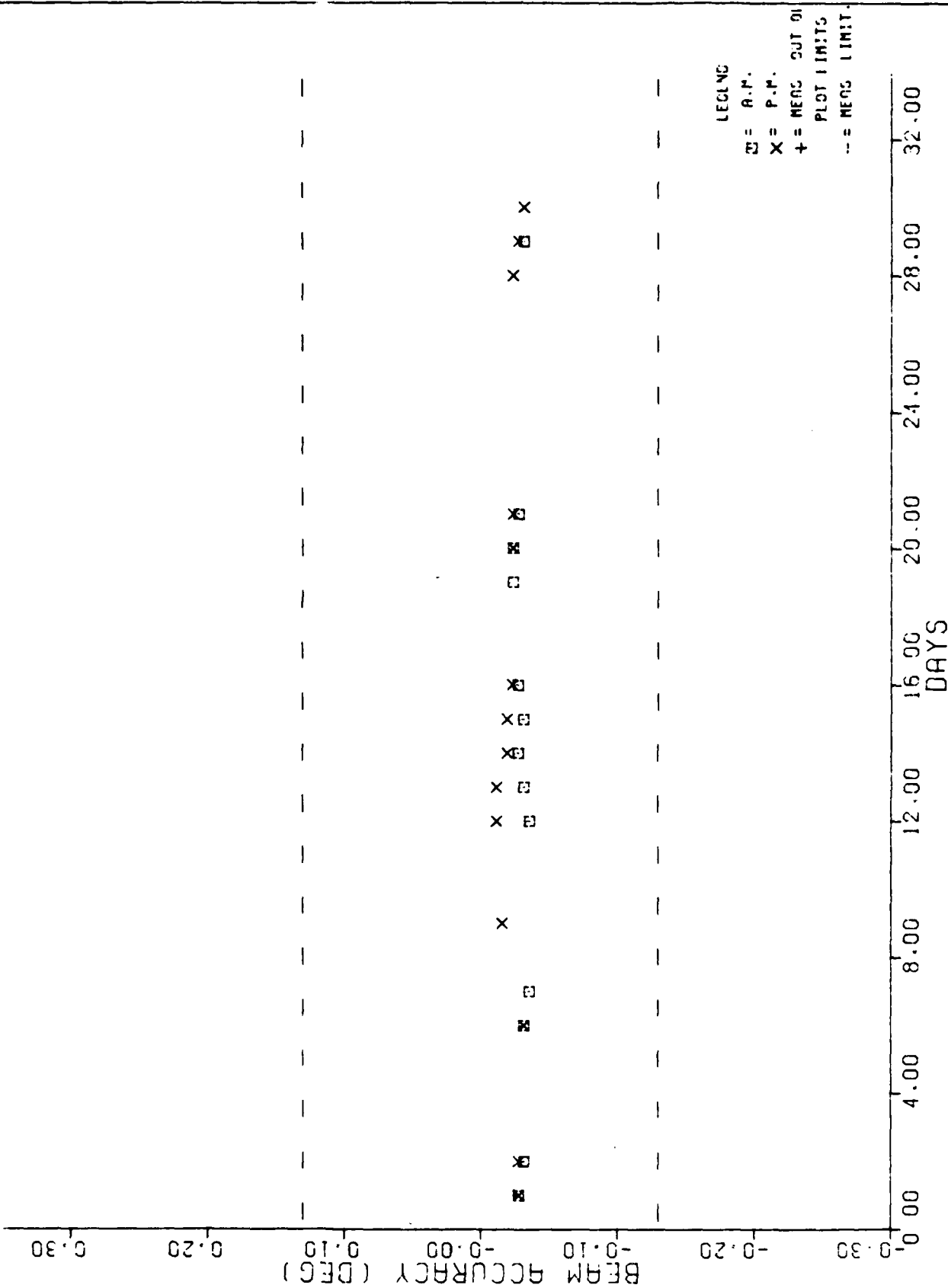


FIGURE C-8. AZIMUTH SUBSYSTEM RMMS DATA MONTHLY PLOT - BEAM ACCURACY PARAMETER

WASHINGTON MLS ELEVATION MONITOR, APR. 1983.

DATA RECORDED AND PROCESSED BY THE FAN TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

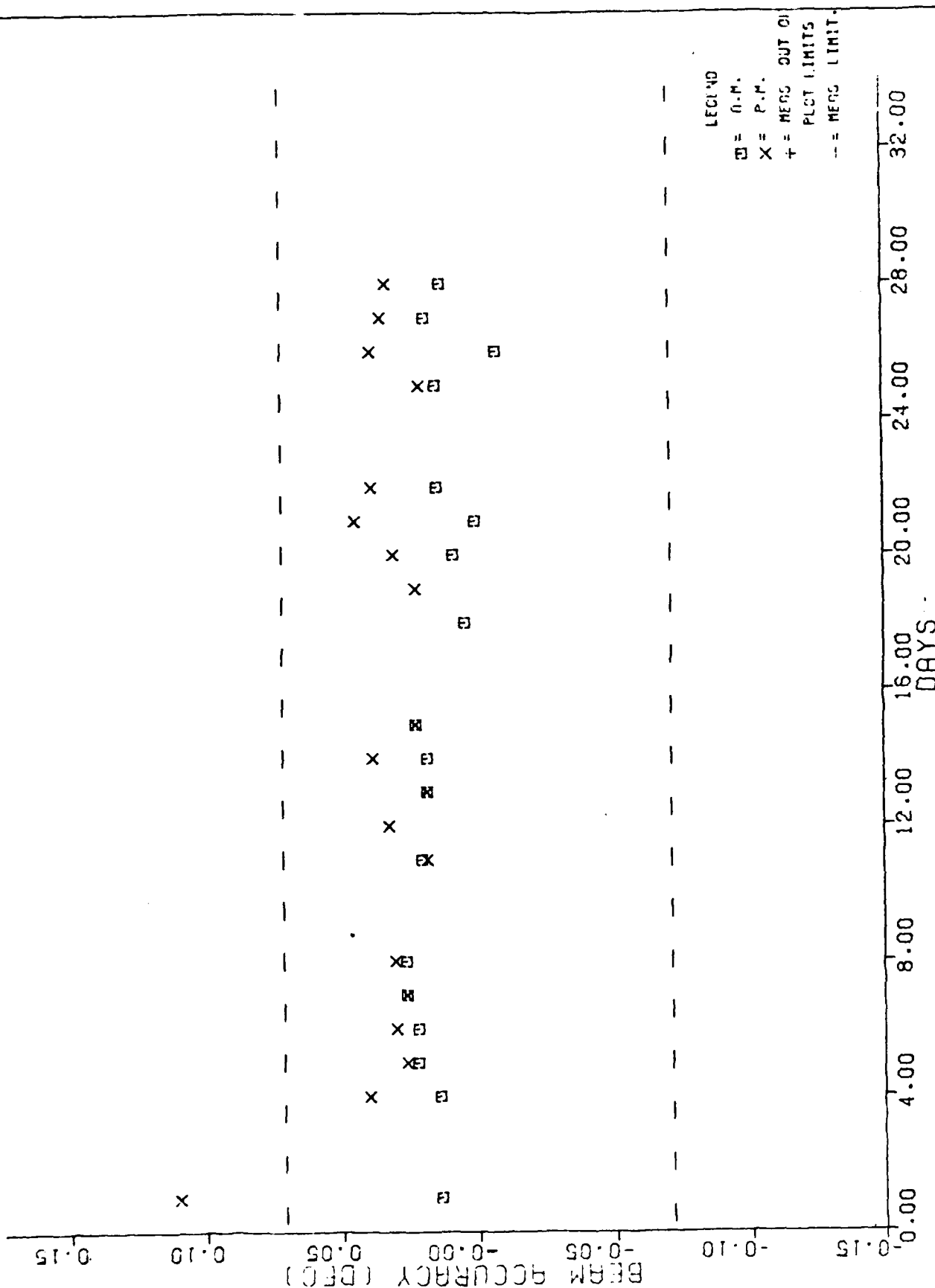


FIGURE C-9. ELEVATION SUBSYSTEM RMS DATA MONTHLY PLOT - BEAM
ACCURACY PARAMETER

APPENDIX D

RMMS DATA YEARLY A.M. AND P.M. PLOTS

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D-11	Azimuth Monitor, July 1982-June 1983, TWTA Power Out Parameter a.m. Plot	D-11
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D-23	Elevation Monitor, July 1981-June 1982, TWTA Power Out Parameter p.m. Plot	D-23
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D-29	Elevation Monitor, July 1982-June 1983, Beam Accuracy Parameter p.m. Plot	D-29
D-30	Elevation Monitor, July 1982-June 1983, Beam ERP Parameter p.m. Plot	D-30
D-31	Elevation Monitor, July 1982-June 1983, TWTA Power Out Parameter p.m. Plot	D-31
D-32	Elevation Monitor, July 1982-June 1983, Antenna Temperature Parameter p.m. Plot	D-32

WASH. MLS AZ. MONITOR: JUL., 1981-JUN., 1982, A.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 09405

0.30
0.20
0.10
-0.00
-0.10
-0.20
-0.30

BEAM ACCURACY (DEG)

JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN

LEGEND

- = A.M.
- X = P.M.
- + = MEAS OUT OF
- = MEAS LIMITS
- = MEAS LIMIT

FIGURE D-1. AZIMUTH MONITOR, JULY 1981-JUNE 1982, BEAM ACCURACY
PARAMETER A.M. PLOT

WACH. M.S. AZ. MONITOR: JUL., 1981-JUN., 1982, A.M. DATA RECORDED AND PROCESSED BY THE F99 TECHNICAL CENTER, ATLANTIC CITY AIRPORT, N.J. 09405

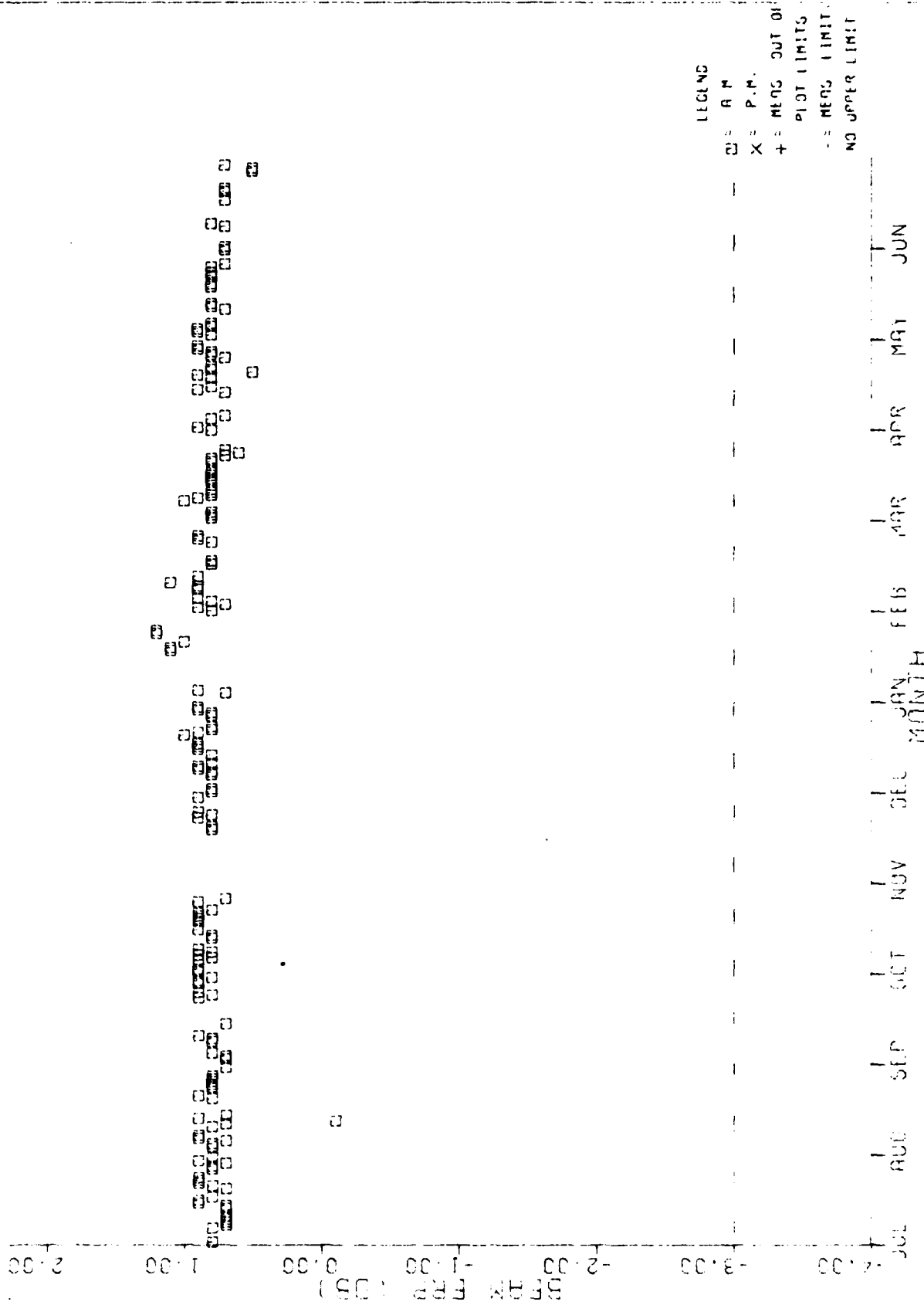


FIGURE D-2. AZIMUTH MONITOR, JULY 1981-JUNE 1982, BEAM ERP
PARAMETER A.M. PLOT

WASH. PLS AZ. MONITOR: JUL., 1981-JUN., 1982, A.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 09405

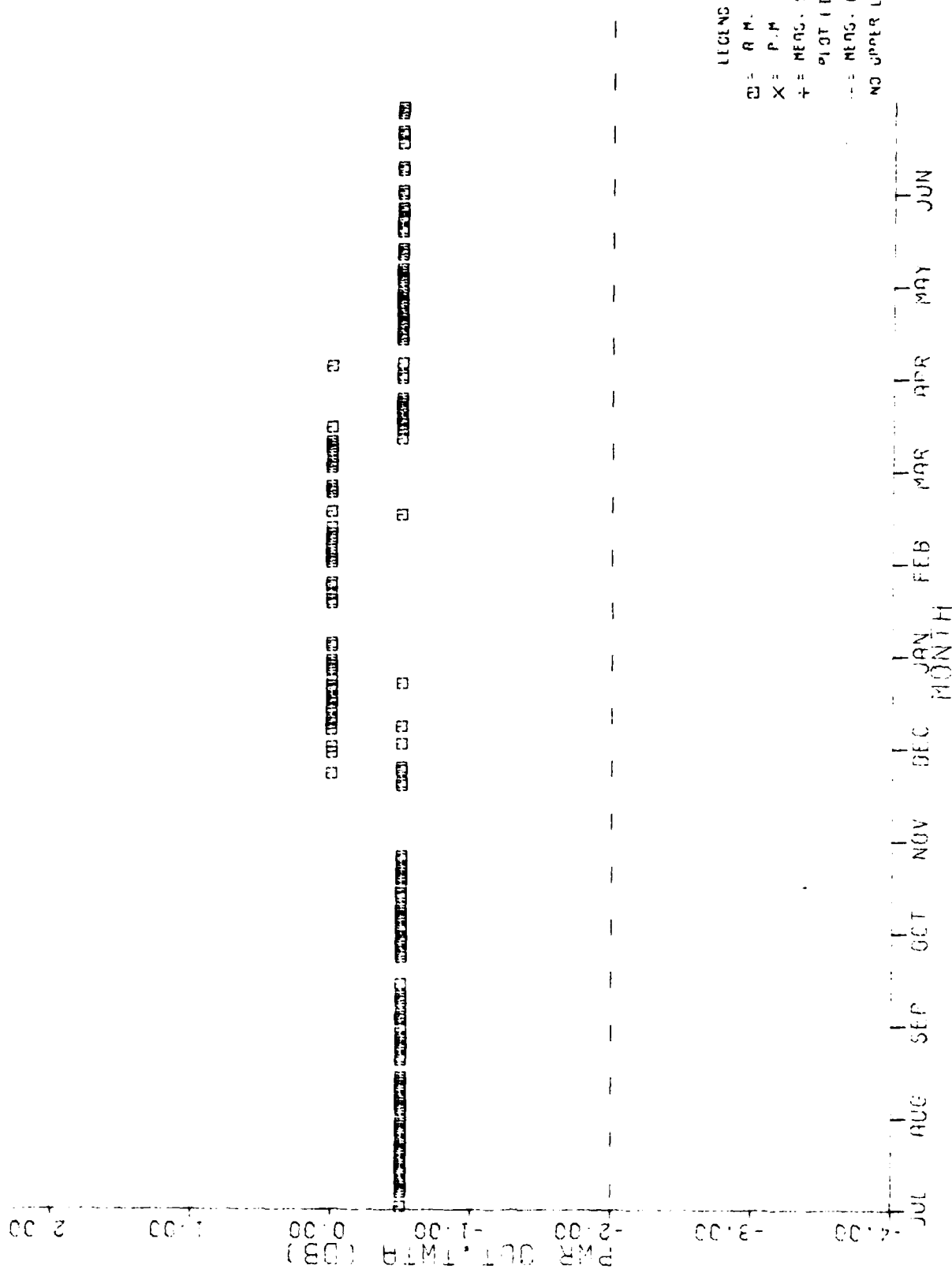


FIGURE D-3. AZIMUTH MONITOR, JULY 1981-JUNE 1982, TWTA POWER OUT PARAMETER A.M. PLOT

WASH. FLS AZ. MONITOR: JUL., 1981-JUN., 1982, A.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 09405

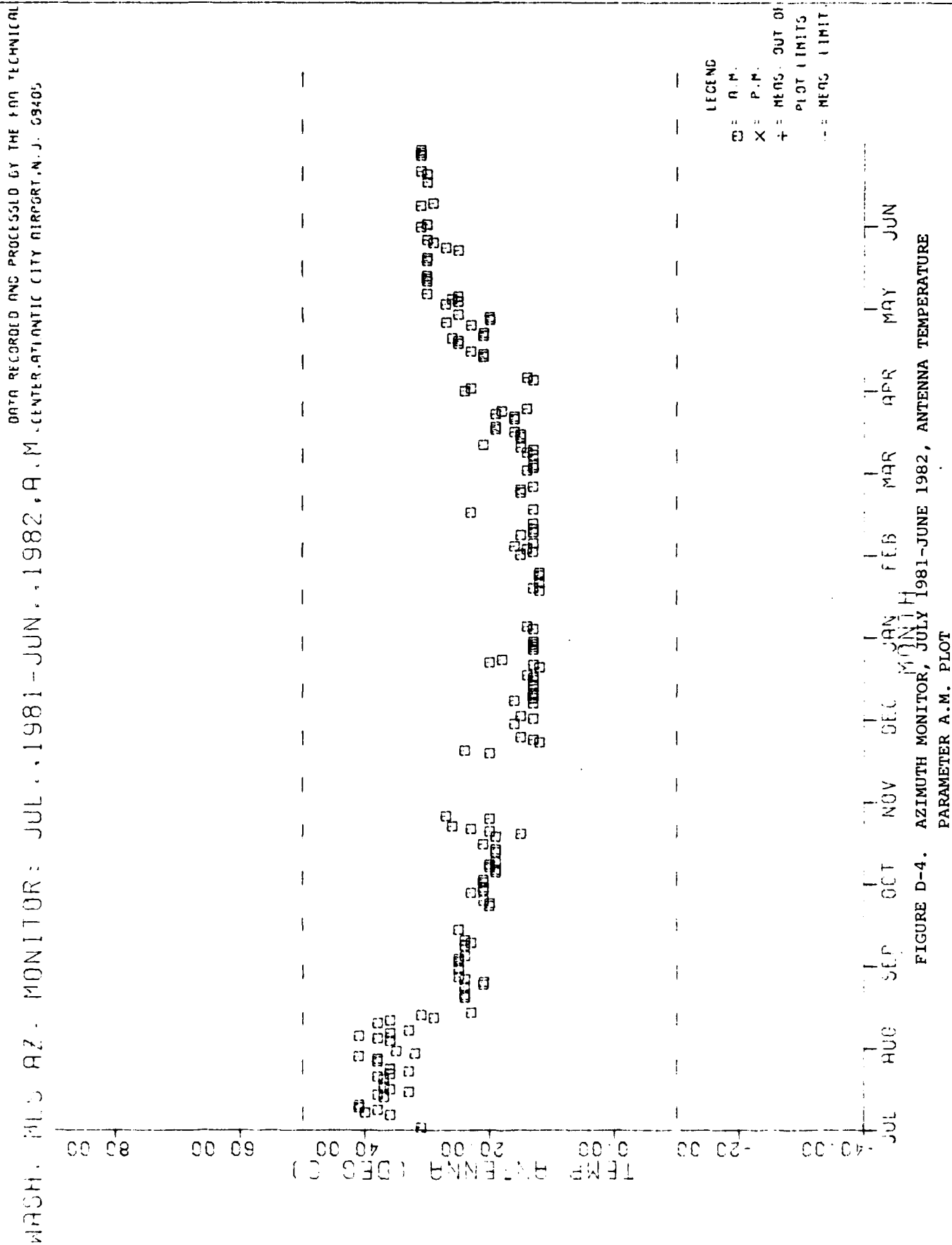


FIGURE D-4. AZIMUTH MONITOR, JULY 1981-JUNE 1982, ANTENNA TEMPERATURE
 PARAMETER A.M. PLOT

WASH. NLS AZ. MONITOR: JUL., 1981-JUN., 1982, P.M. *
 DATA RECORDED AND PROCESSED BY THE FAA TECHNICAL
 CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

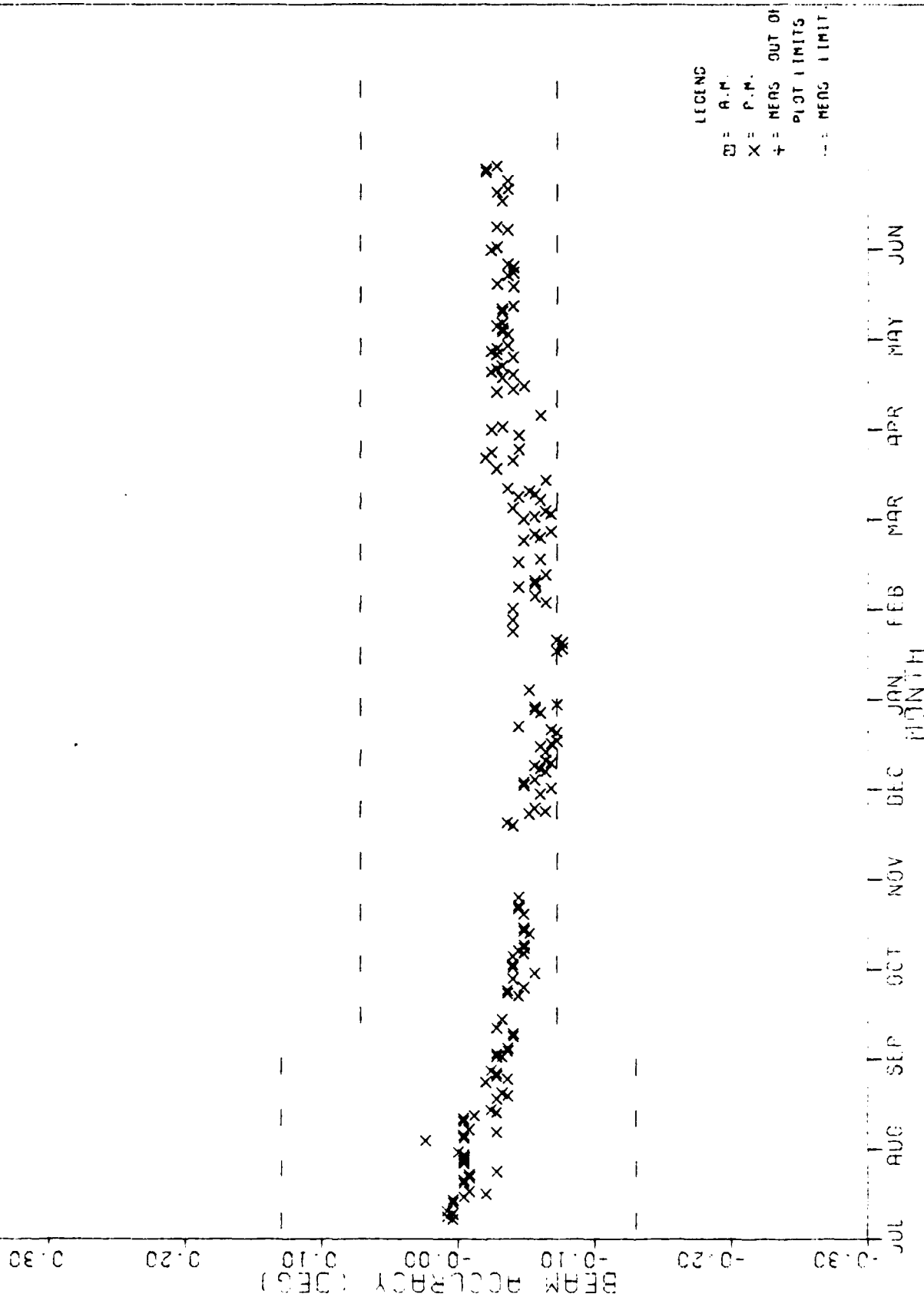


FIGURE D-5. AZIMUTH MONITOR, JULY 1981-JUNE 1982, BEAM ACCURACY
 PARAMETER P.M. PLOT

WACH. M15 AZ. MONITOR: JUL., 1981-JUN., 1982, P.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

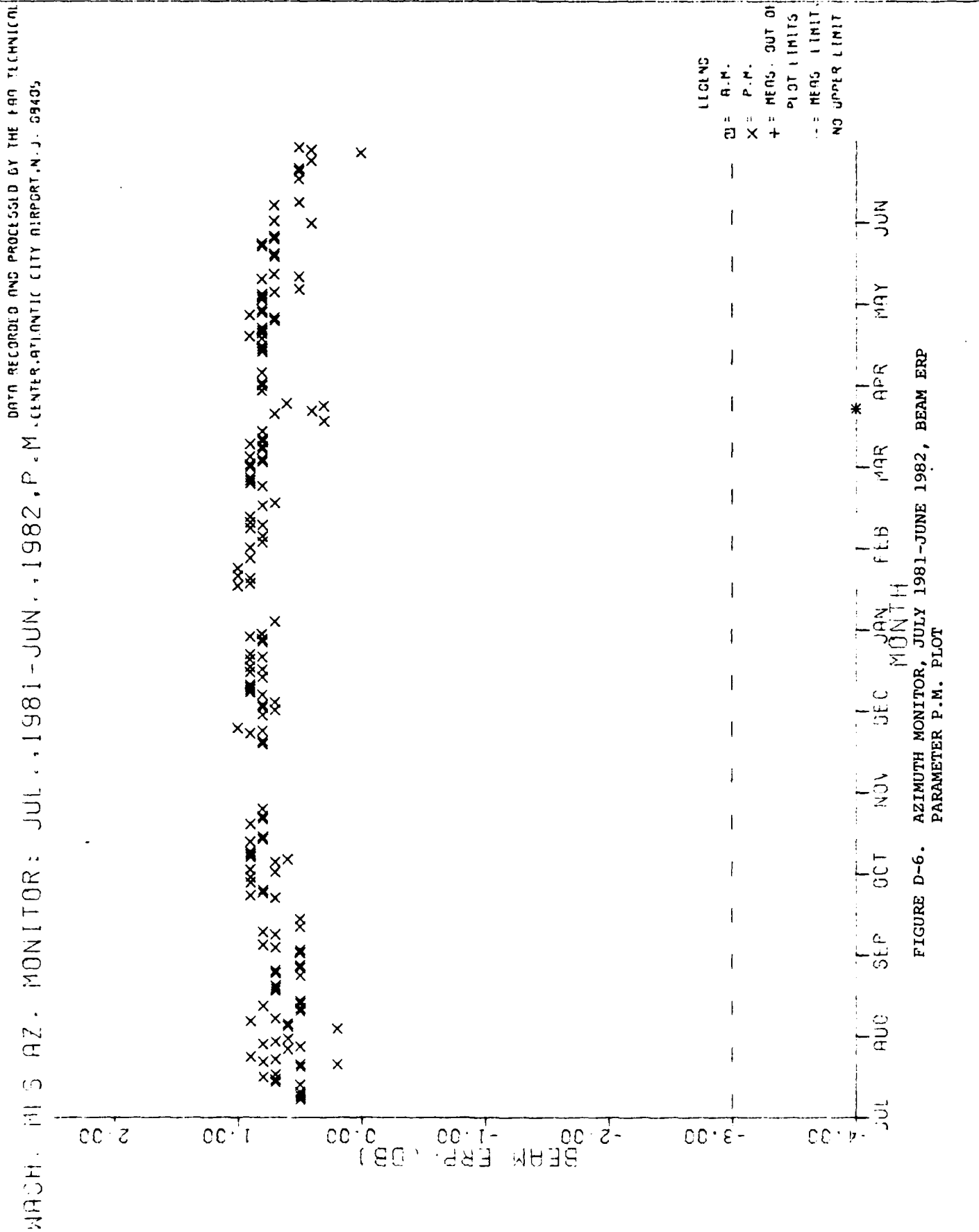


FIGURE D-6. AZIMUTH MONITOR, JULY 1981-JUNE 1982, BEAM ERP
PARAMETER P.M. PLOT

WASH. MLS AZ. MONITOR: JUL. 1981-JUN. 1982, P. M
DATA RECORDED AND PROCESSED BY THE FAN TECHNICAL
CENTER, ATLANTIC CITY AIRPORT, N. J. 08405

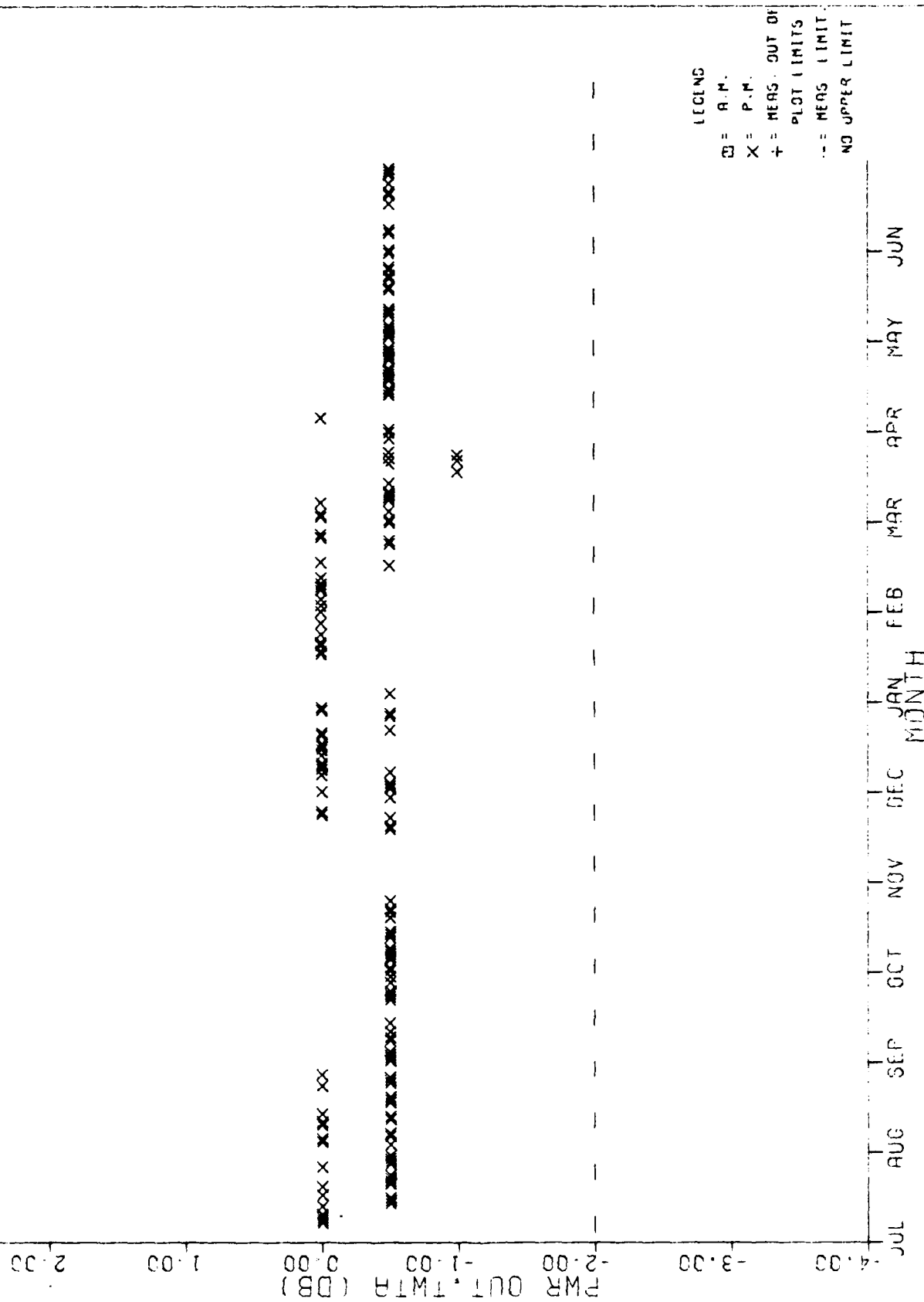


FIGURE D-7. AZIMUTH MONITOR, JULY 1981-JUNE 1982, TWTA POWER OUT
PARAMETER P.M. PLOT

WASH. MLS AZ. MONITOR: JUL., 1981-JUN., 1982, P.M. DATA RECORDED AND PROCESSED BY THE FAA TECHNICAL CENTER, ATLANTIC CITY AIRPORT, N. J. 08405

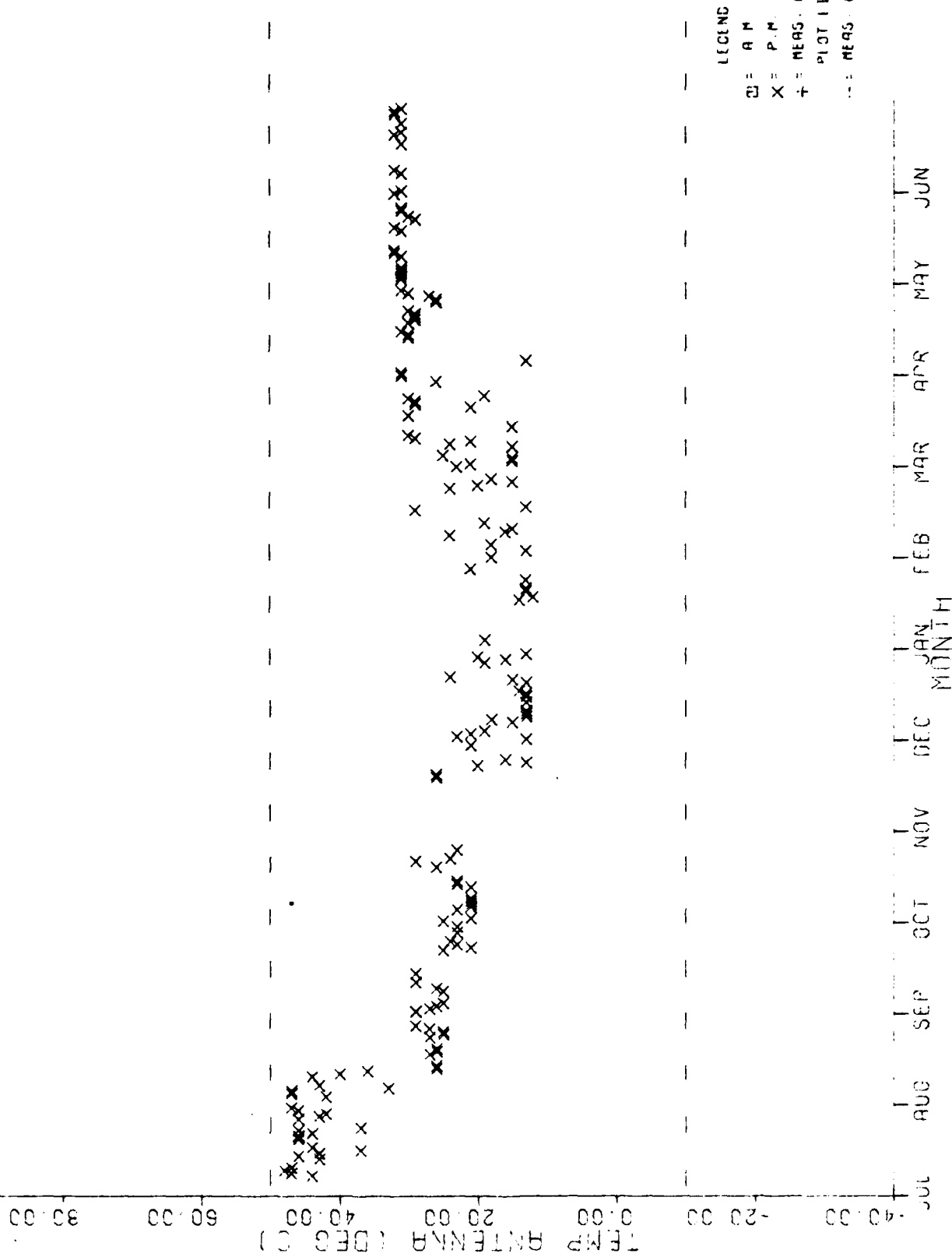


FIGURE D-8. AZIMUTH MONITOR, JULY 1981-JUNE 1982, ANTENNA TEMPERATURE PARAMETER P.M. PLOT

THE NEW YORK PUBLIC LIBRARY
ASTOR LENOX TILDEN FOUNDATION
155 E. 42ND STREET
NEW YORK 17, N.Y.

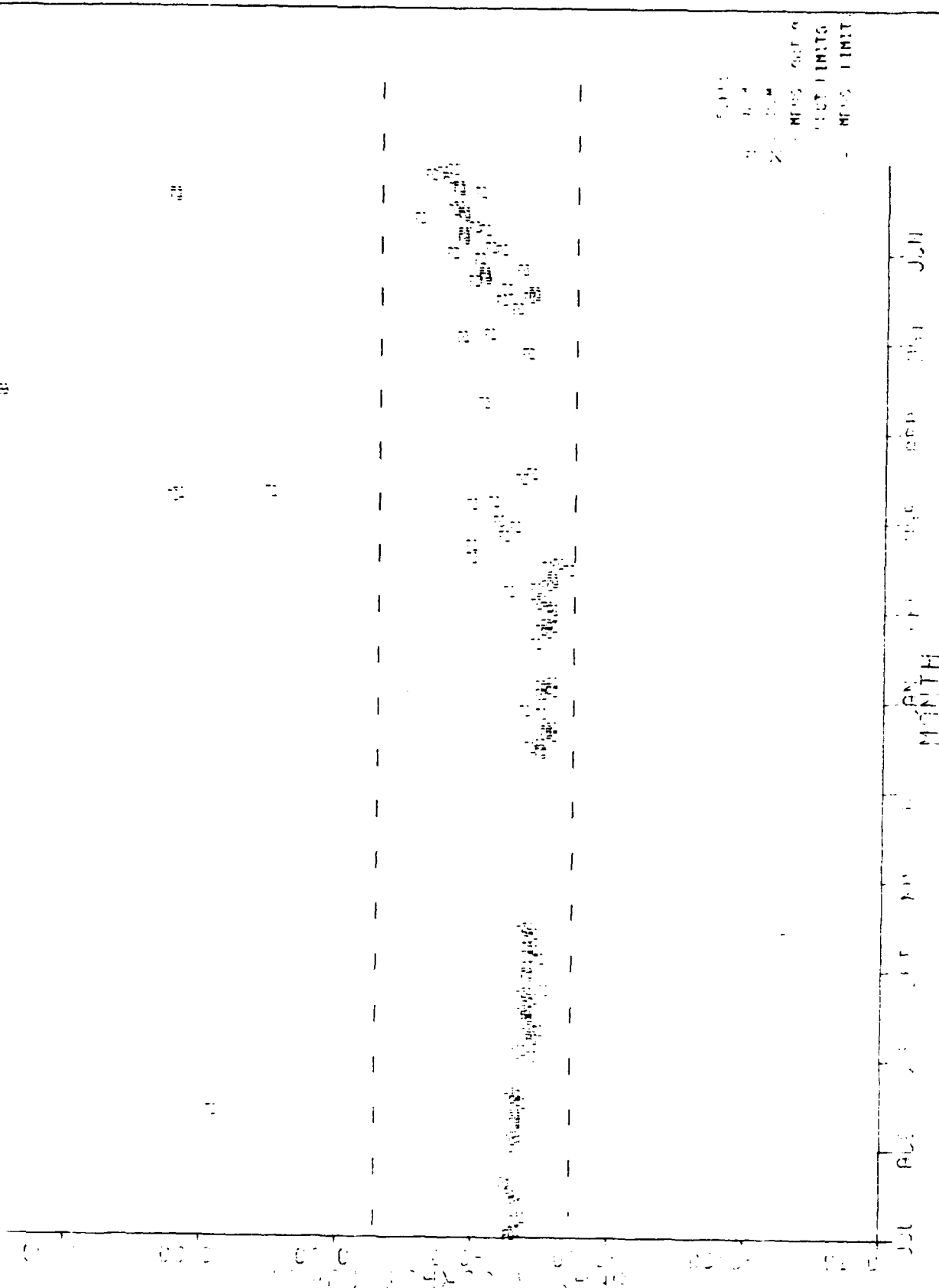


FIGURE D-9. AZIMUTH MONITOR, JULY 1982-JUNE 1983, BEAM ACCURACY
PARAMETER A.M. PLOT

OF A BUREAU OF PUBLIC AFFAIRS, THE F.B.I. RECORDED
CENTRO-ATLANTIC CITY BUREAU, N. J. 08002.

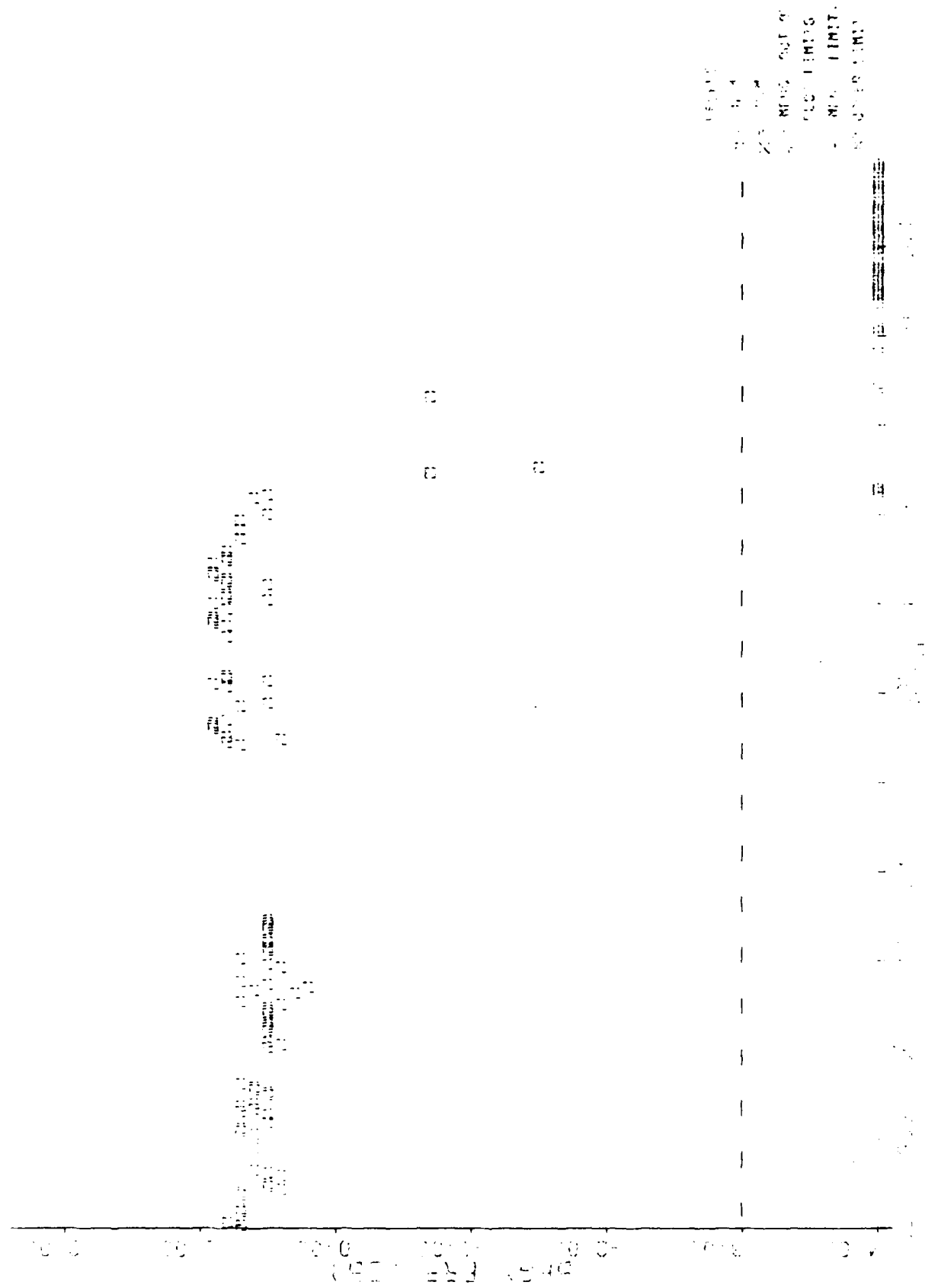


FIGURE D-10. AZIMUTH MONITOR, JULY 1982-JUNE 1983, BEAM ERP
PARAMETER A.M. PLOT

[illegible]

UNITED STATES
DEPARTMENT OF JUSTICE
FEDERAL BUREAU OF INVESTIGATION

16-000000 MONITOR JULY 1982-JUNE 1983, ANTENNA TEMPERATURE
 1000 800 600 400 200 0 0 100 200 300 400 500 600 700 800 900 1000

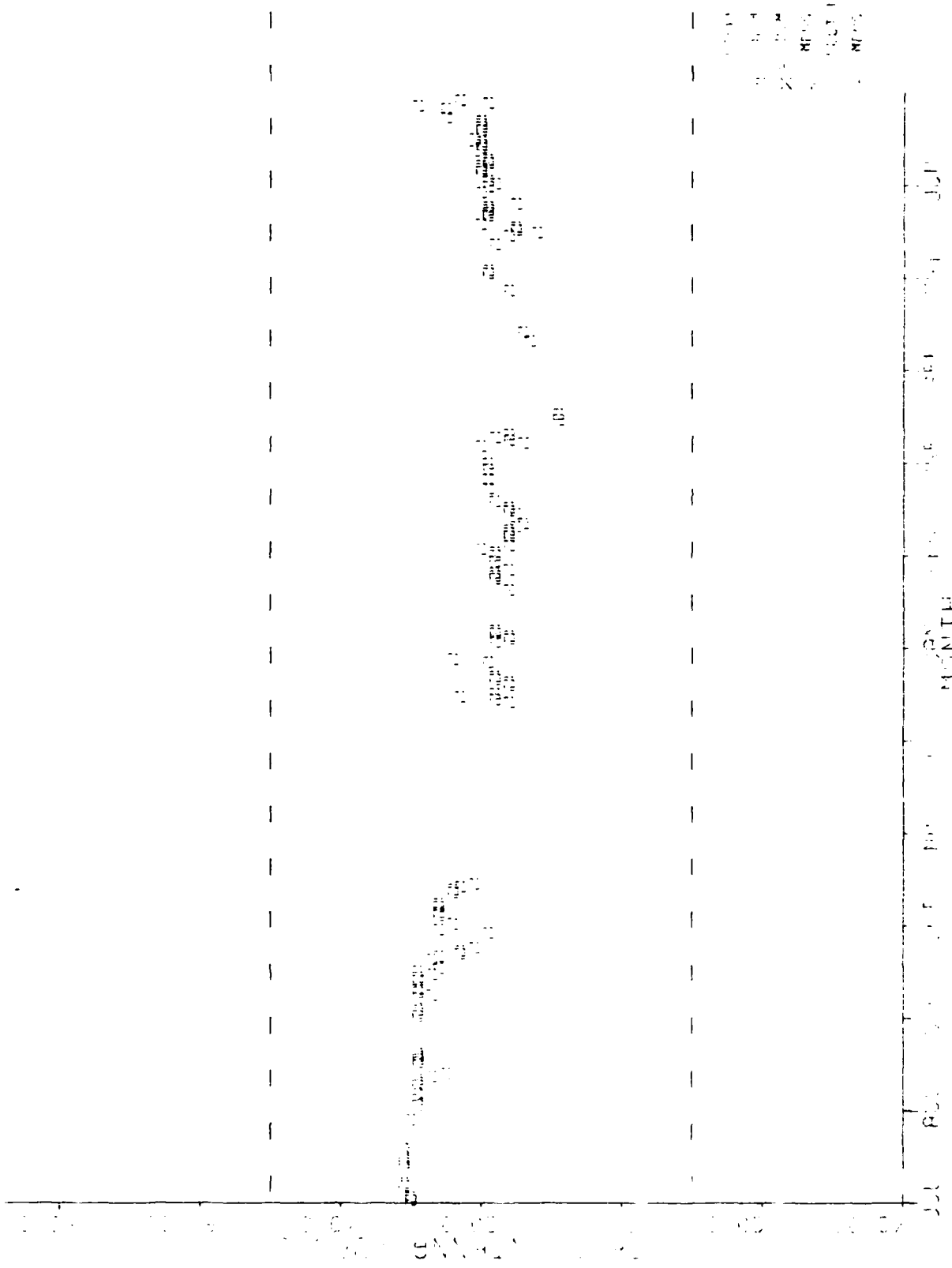


FIGURE D-12. AZIMUTH MONITOR, JULY 1982-JUNE 1983, ANTENNA TEMPERATURE
 PARAMETER A.M. PLOT

FROM THE 62. MONITOR - JULY 1982-JUNE 1983, P.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 08403.

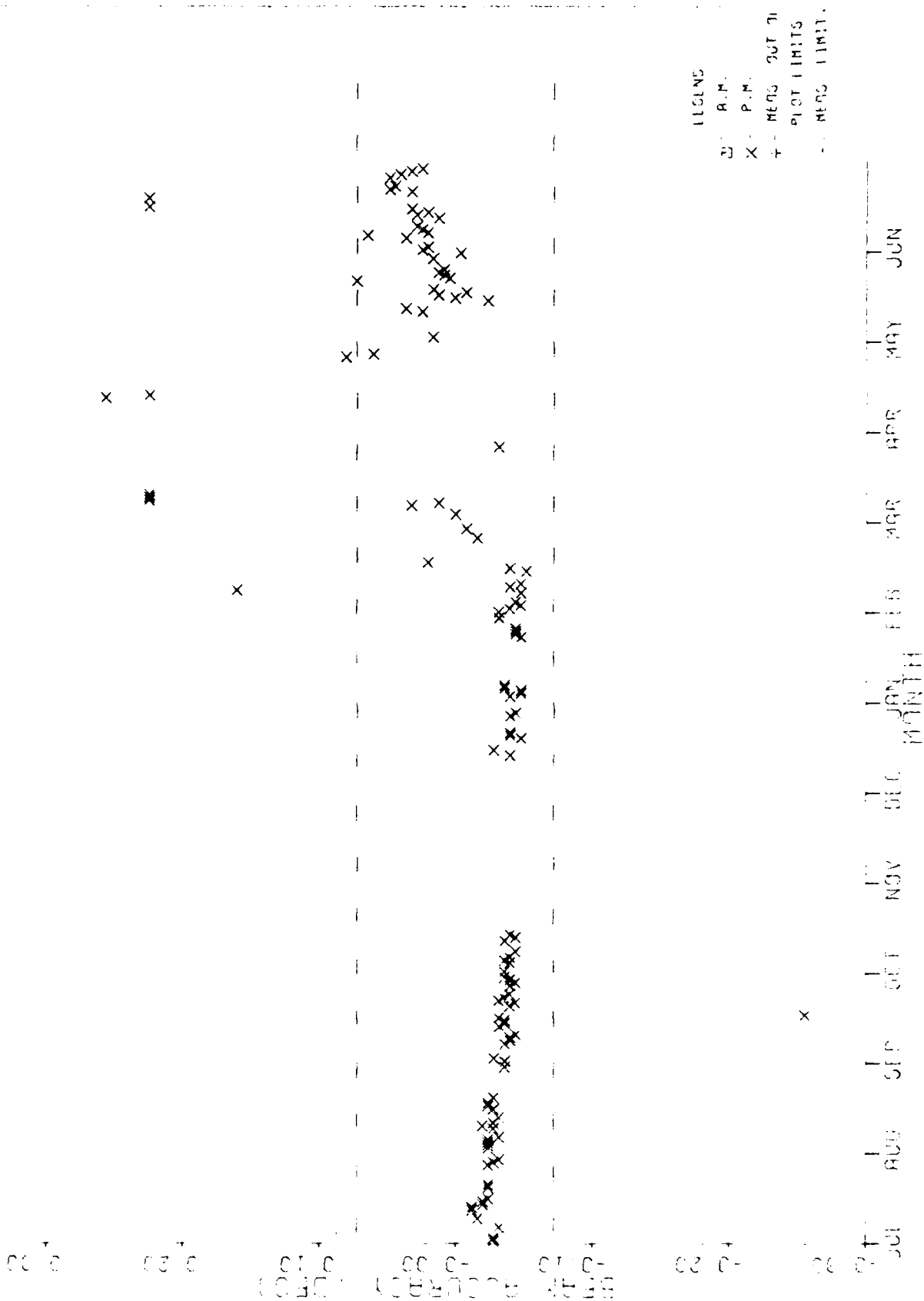


FIGURE D-13. AZIMUTH MONITOR, JULY 1982-JUNE 1983, BEAM ACCURACY
PARAMETER P.M. PLOT

WADSWORTH AIRCRAFT MONITOR: JULY 1982-JUNE 1983, P.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

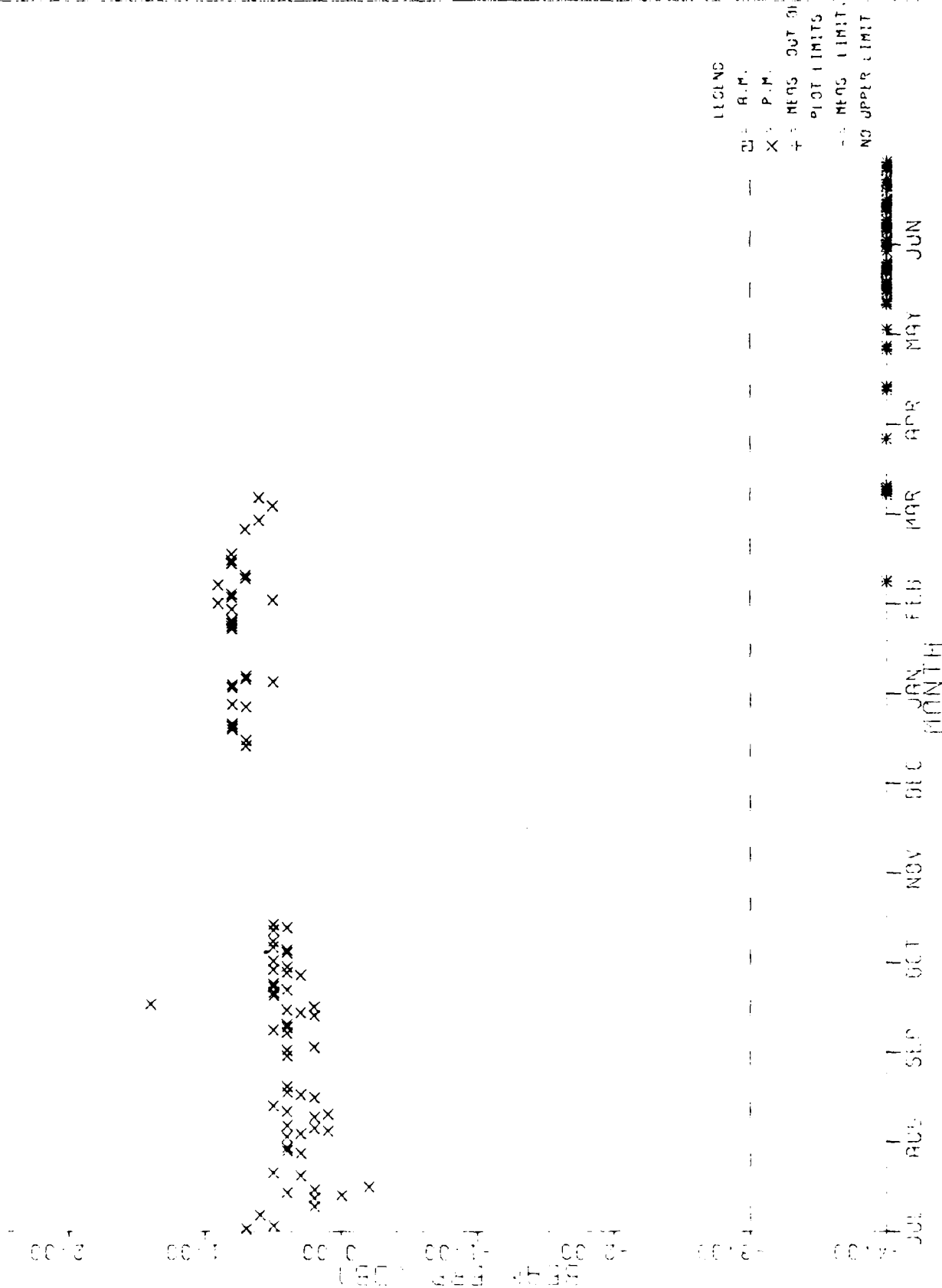


FIGURE D-14. AZIMUTH MONITOR, JULY 1982-JUNE 1983, BEAM ERP
PARAMETER P.M. PLOT

WASH. FILE AZ - MONITOR: JUL - 1982 - JUN. 1983. P. MCINTIER, ATLANTIC CITY AIRPORT, N.J. 08405

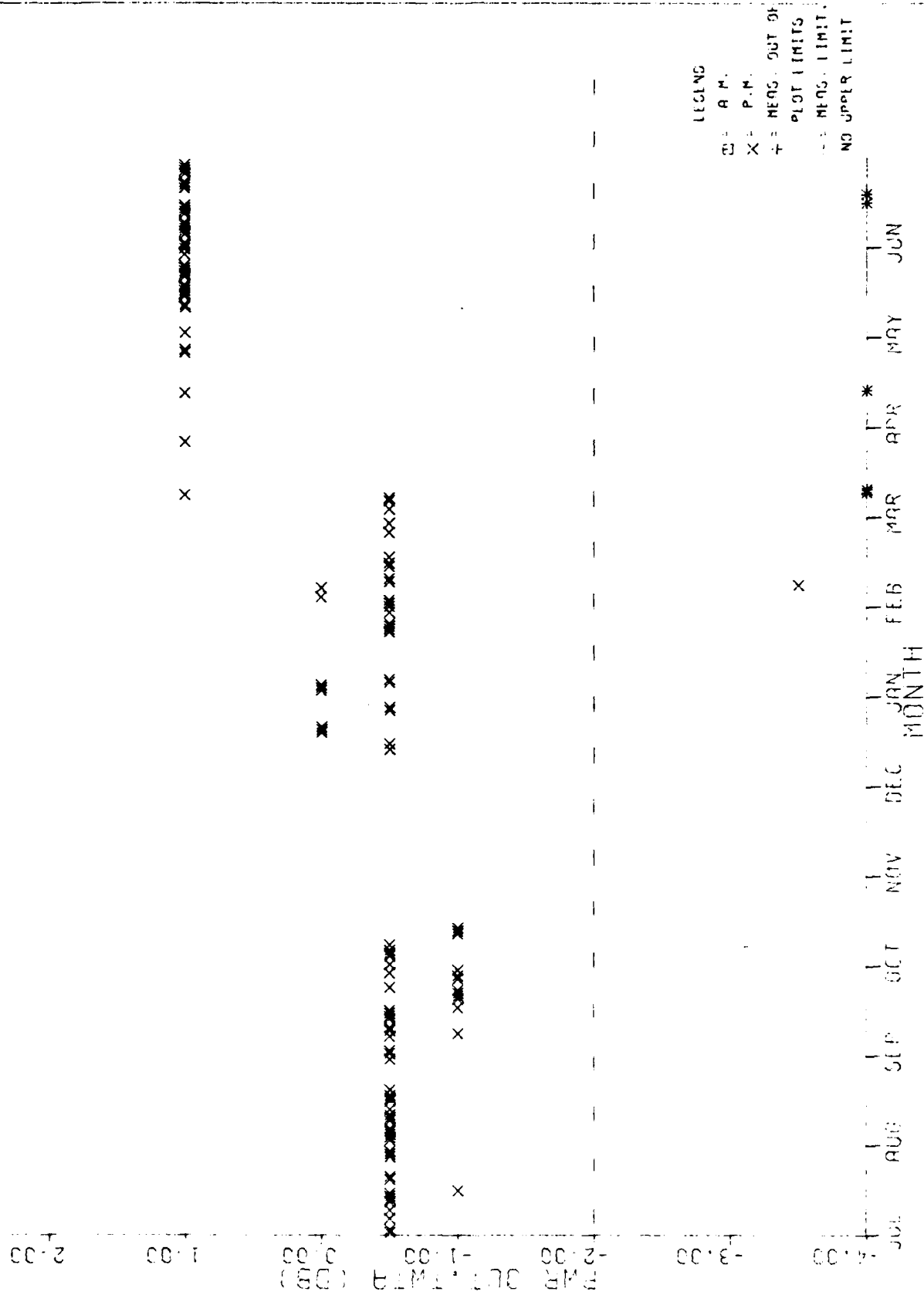


FIGURE D-15. AZIMUTH MONITOR, JULY 1982-JUNE 1983, TWTA POWER OUT
PARAMETER P.M. PLOT

WASH. MLS AZ. MONITOR: JUL. 1982-JUN. 1983. P. MCENTER, ATLANTIC CITY AIRPORT, N.J. 08405

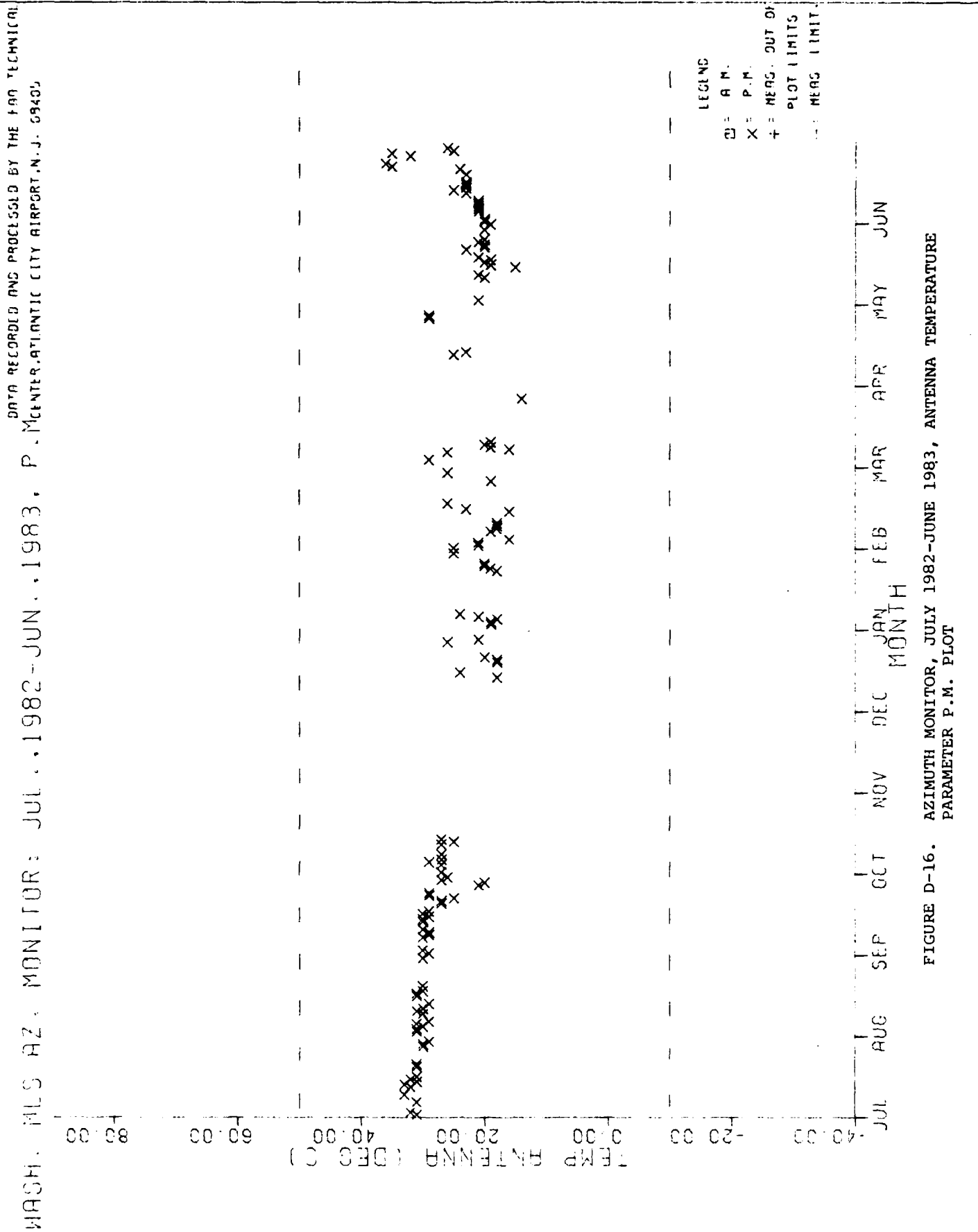


FIGURE D-16. AZIMUTH MONITOR, JULY 1982-JUNE 1983, ANTENNA TEMPERATURE
 PARAMETER P.M. PLOT

WACH. PLUS EL. MONITOR: JUL., 1981-JUN., 1982, A.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 09405

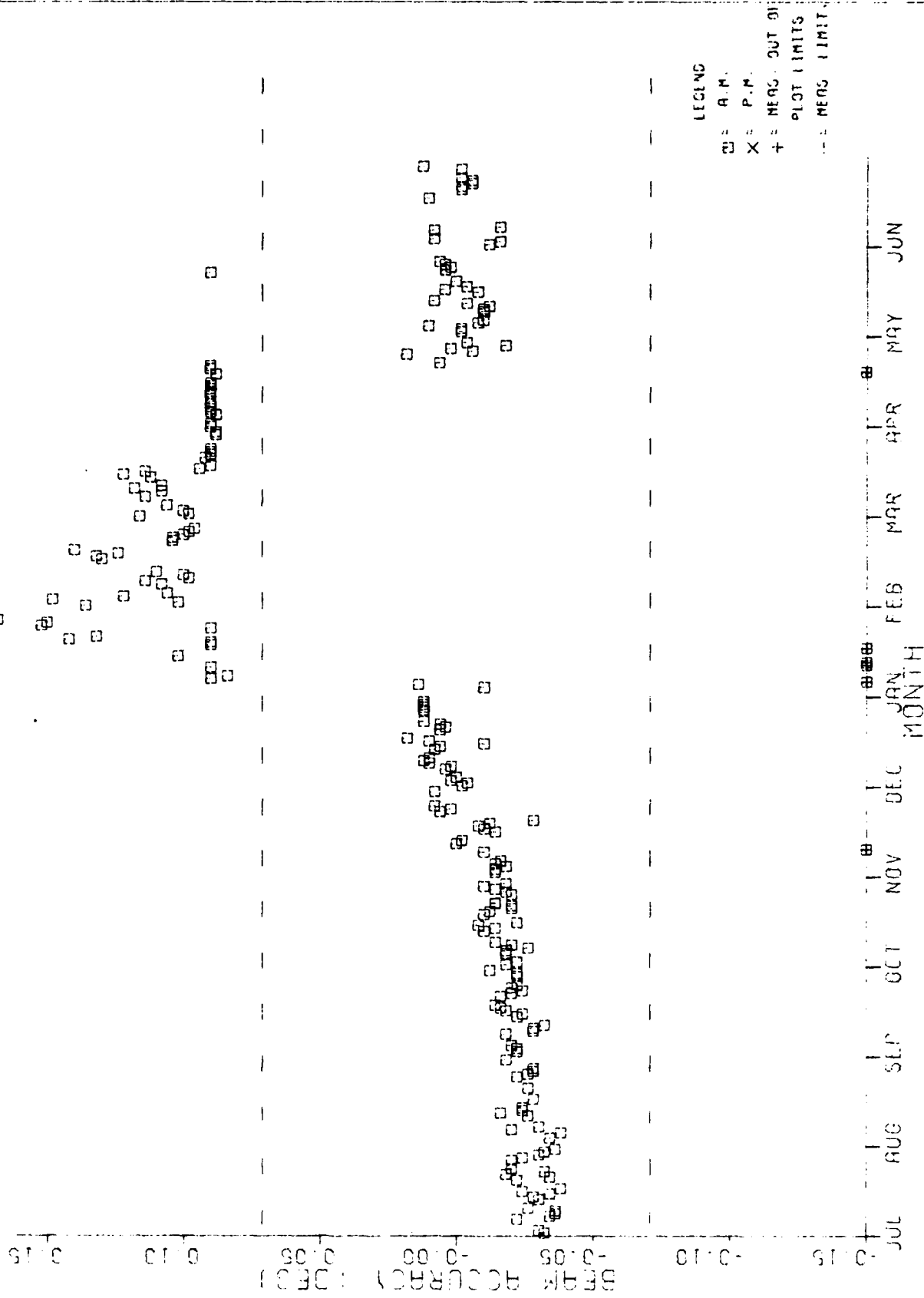


FIGURE D-17. ELEVATION MONITOR, JULY 1981-JUNE 1982, BEAM ACCURACY PARAMETER A.M. PLOT

DATA RECORDED AND PROCESSED BY THE FAA TECHNICAL CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

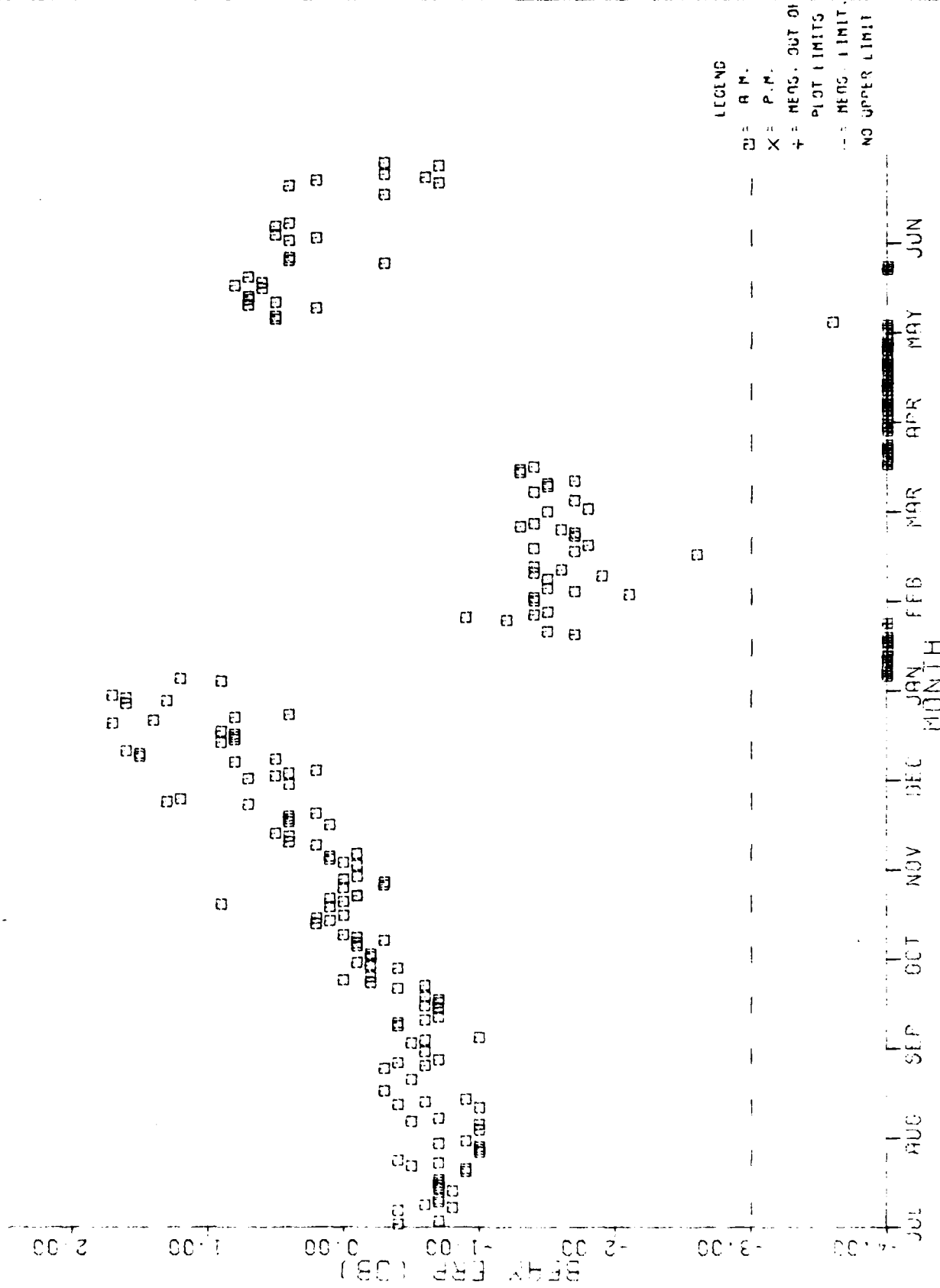


FIGURE D-18. ELEVATION MONITOR, JULY 1981-JUNE 1982, BEAM ERP
PARAMETER A.M. PLOT

WACH. PLS EL. MONITOR: JUL., 1981-JUN., 1982, A.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 09405

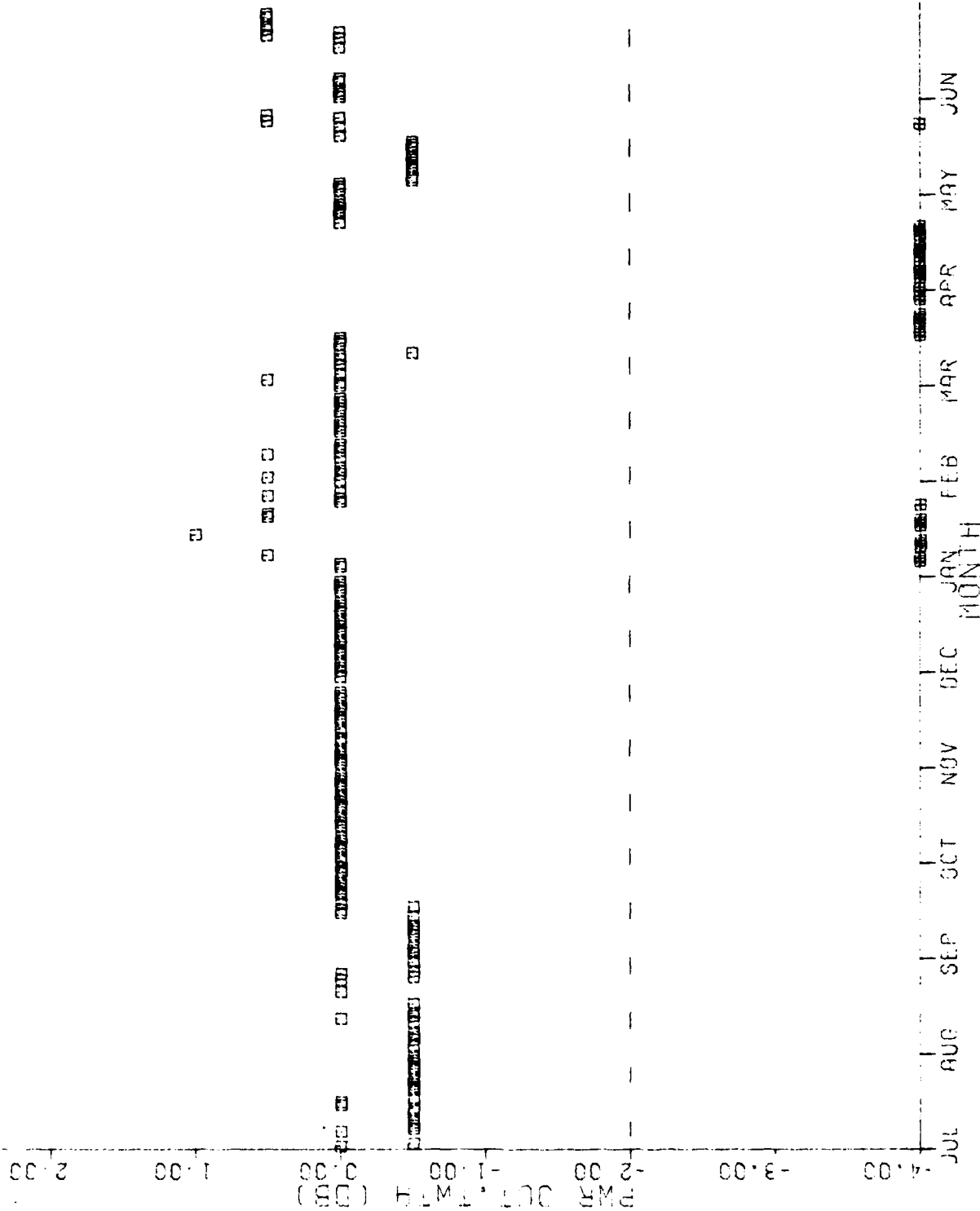


FIGURE D-19. ELEVATION MONITOR, JULY 1981-JUNE 1982, TWTA POWER OUT PARAMETER A.M. PLOT

WASH. FLS EL. MONITOR: JUL., 1981-JUN., 1982, A.M. DATA RECORDED AND PROCESSED BY THE F-99 TECHNICAL CENTER, ATLANTIC CITY AIRPORT, N. J. 08405

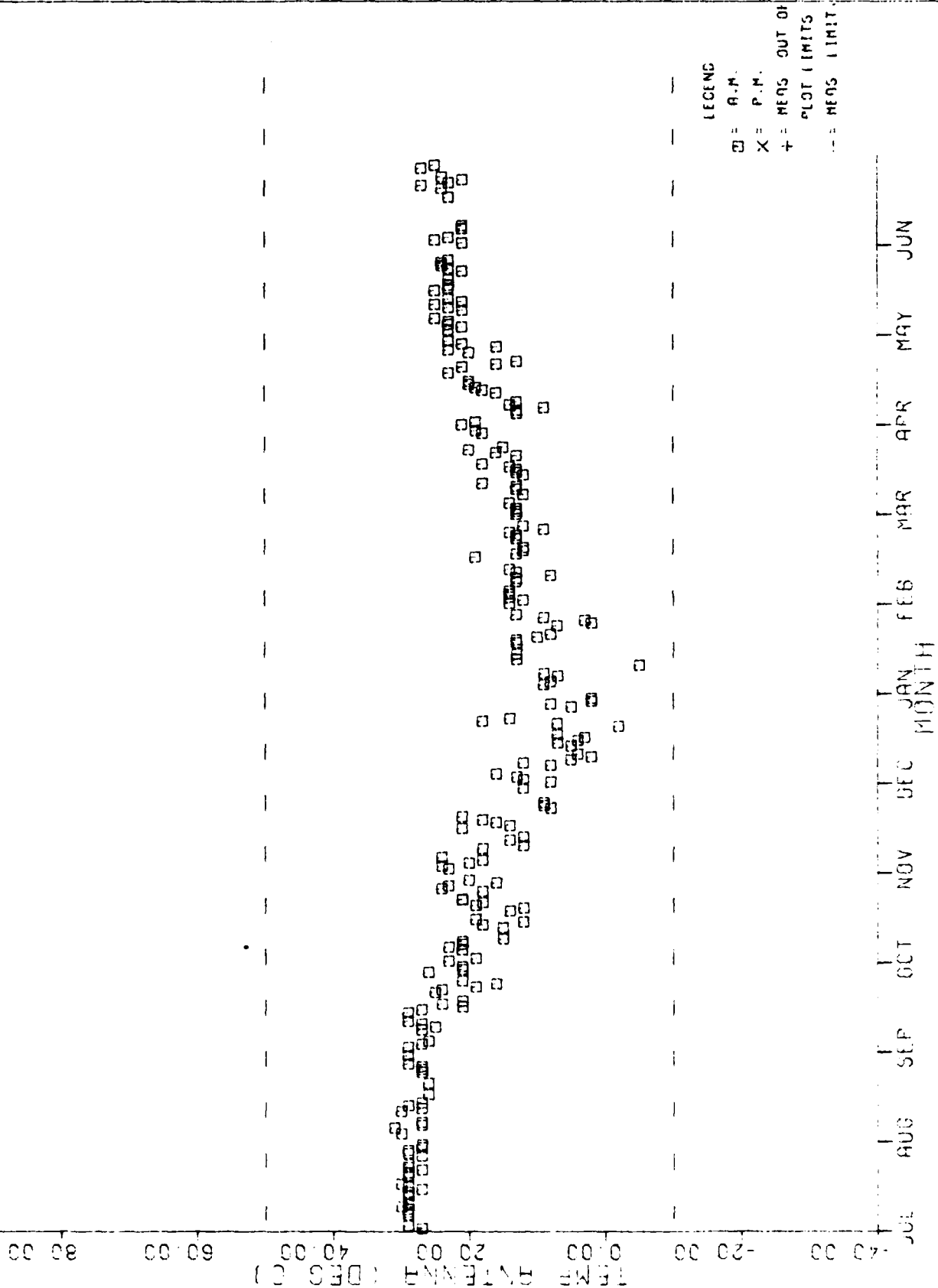


FIGURE D-20. ELEVATION MONITOR, JULY 1981-JUNE 1982, ANTENNA TEMPERATURE
PARAMETER A.M. PLOT

WACH. MIC EL. MONITOR: JUL., 1981-JUN., 1982, P.M. DATA RECORDED AND PROCESSED BY THE FAA TECHNICAL CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

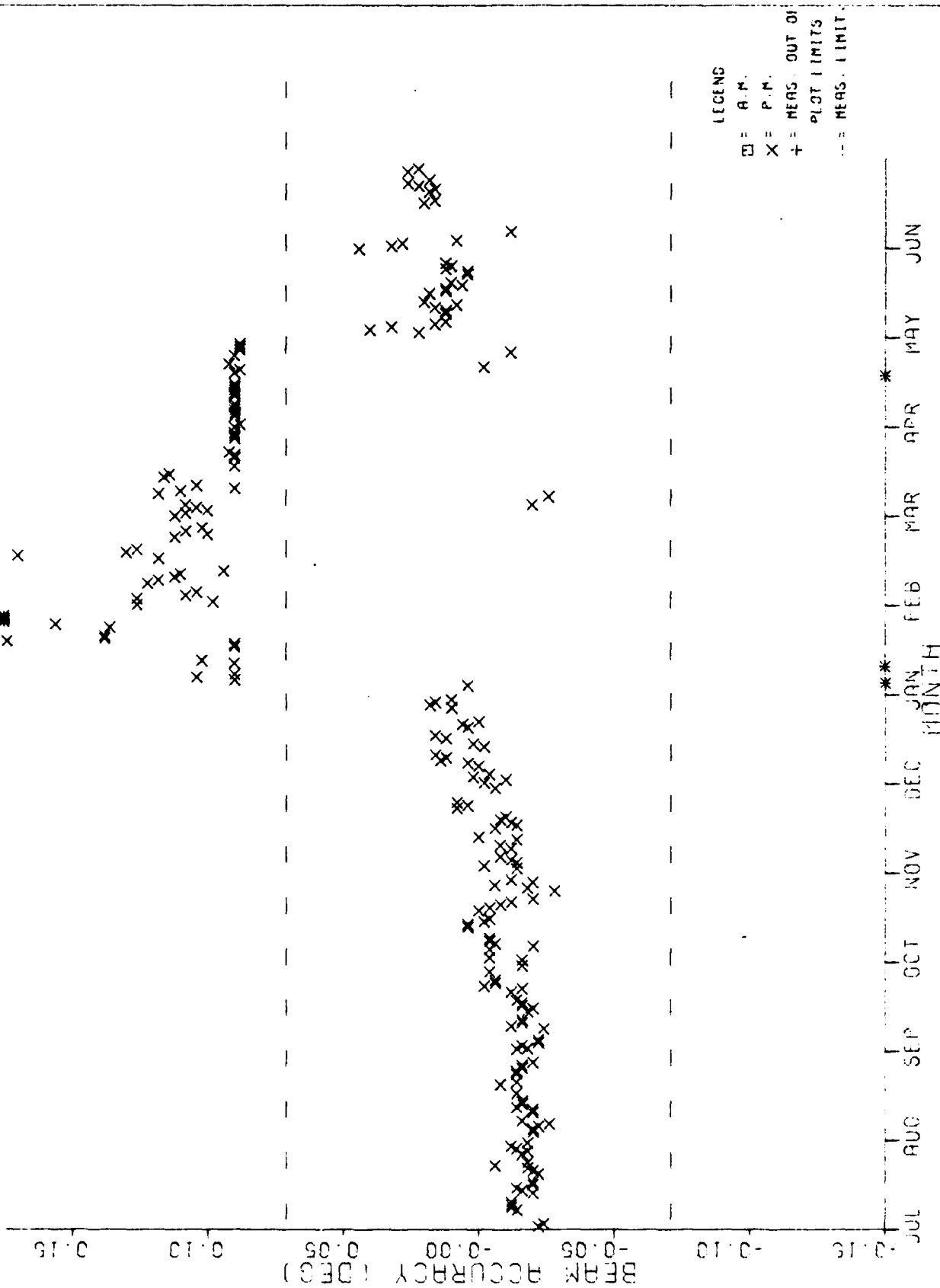
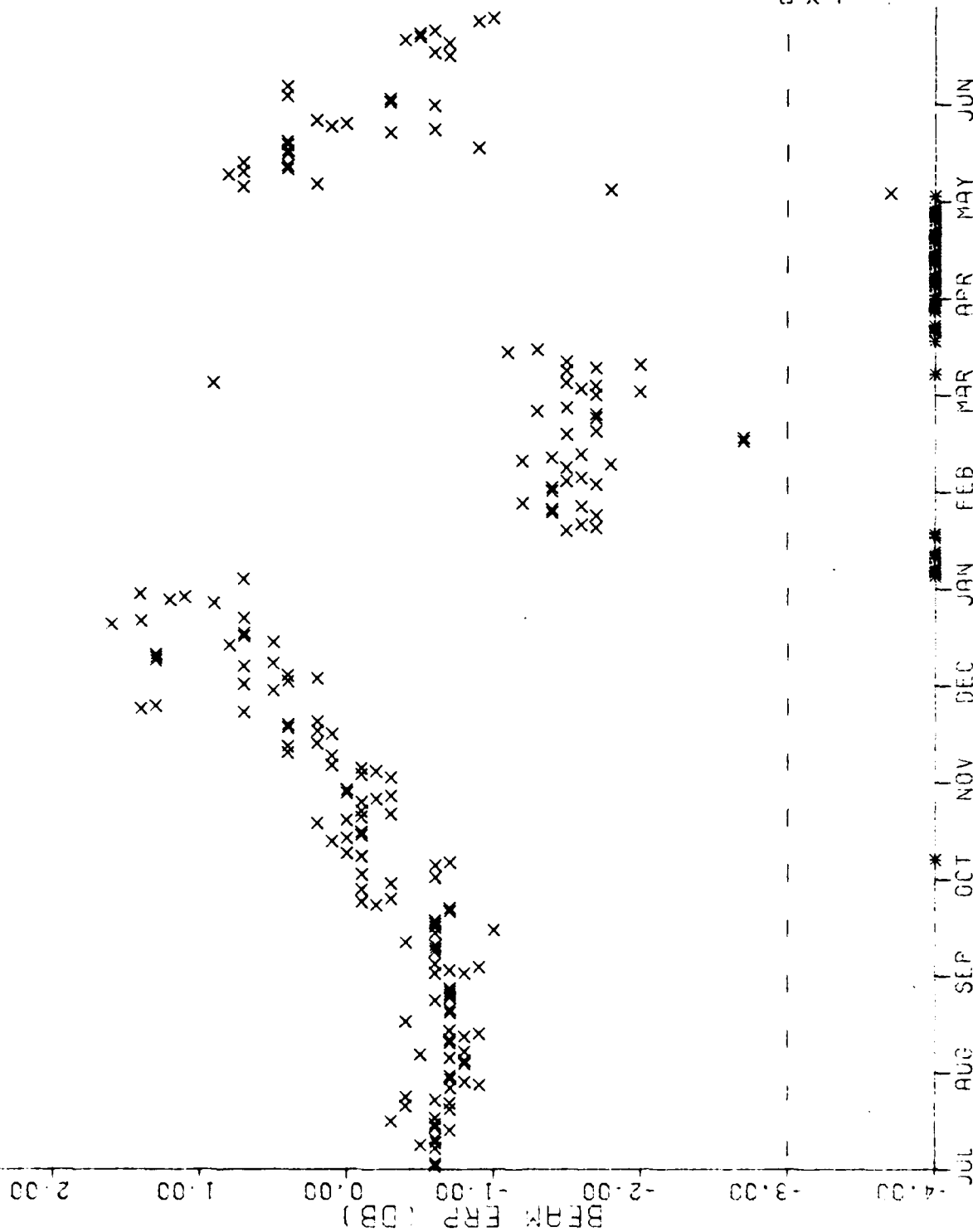


FIGURE D-21. ELEVATION MONITOR, JULY 1981-JUNE 1982, BEAM ACCURACY
PARAMETER P.M. PLOT

WASH. PLS EL. MONITOR: JUL., 1981-JUN., 1982, P.M. DATA RECORDED AND PROCESSED BY THE F99 TECHNICAL CENTER, ATLANTIC CITY AIRPORT, N.J. 08405



LEGEND
 + = A.M.
 x = P.M.
 + = MEAS. OUT OF
 PLOT LIMITS
 - = MEAS. LIMIT
 NO UPPER LIMIT

FIGURE D-22. ELEVATION MONITOR, JULY 1981-JUNE 1982, BEAM ERP
 PARAMETER P.M. PLOT

WASH. FLS EL. MONITOR: JUL., 1981-JUN., 1982, P.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

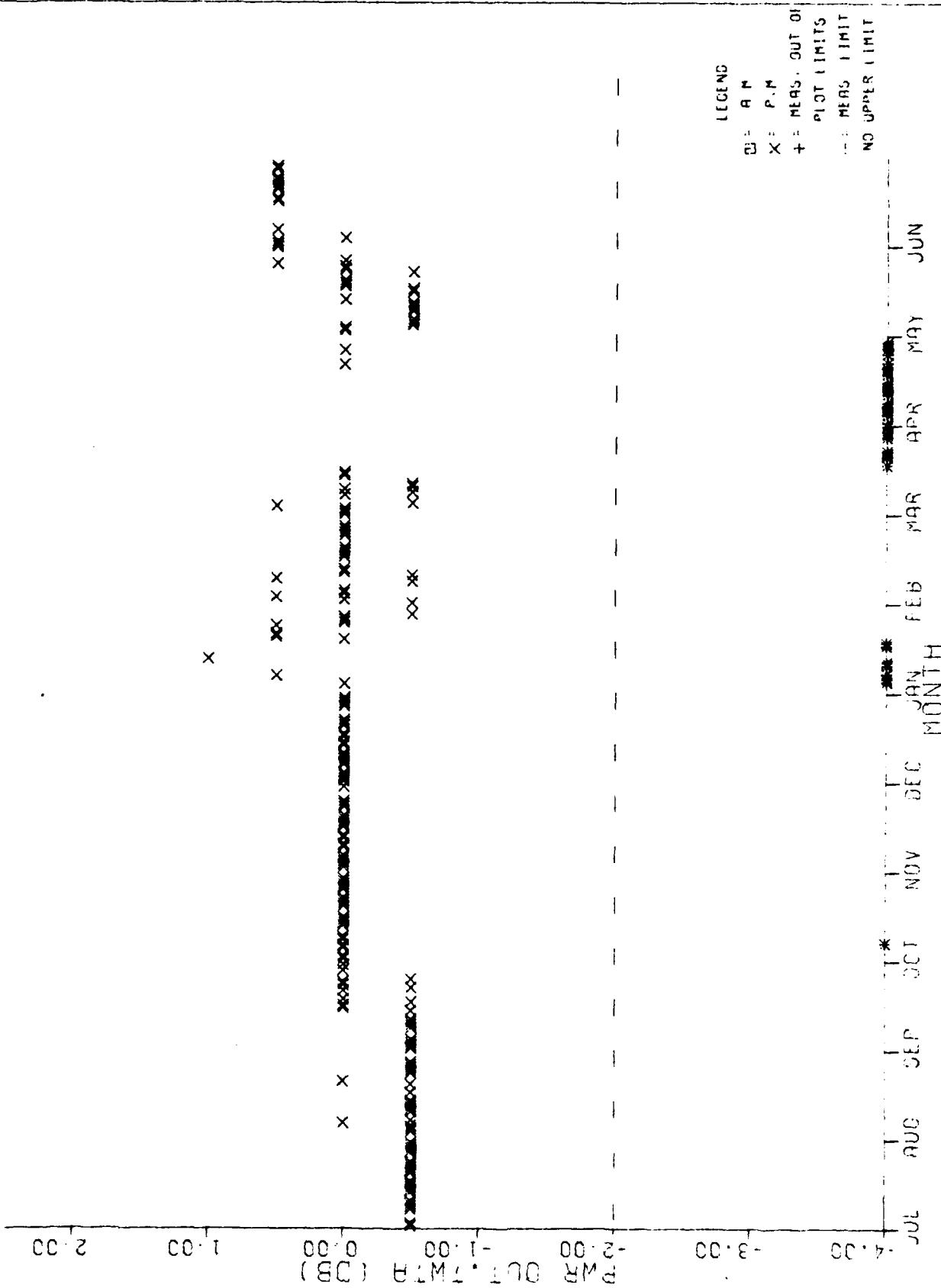


FIGURE D-23. ELEVATION MONITOR, JULY 1981-JUNE 1982, TWTA POWER OUT PARAMETER P.M. PLOT

WACH. PLS EL. MONITOR: JUL., 1981-JUN., 1982, P.M. *
 DATA RECORDED AND PROCESSED BY THE FAA TECHNICAL
 CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

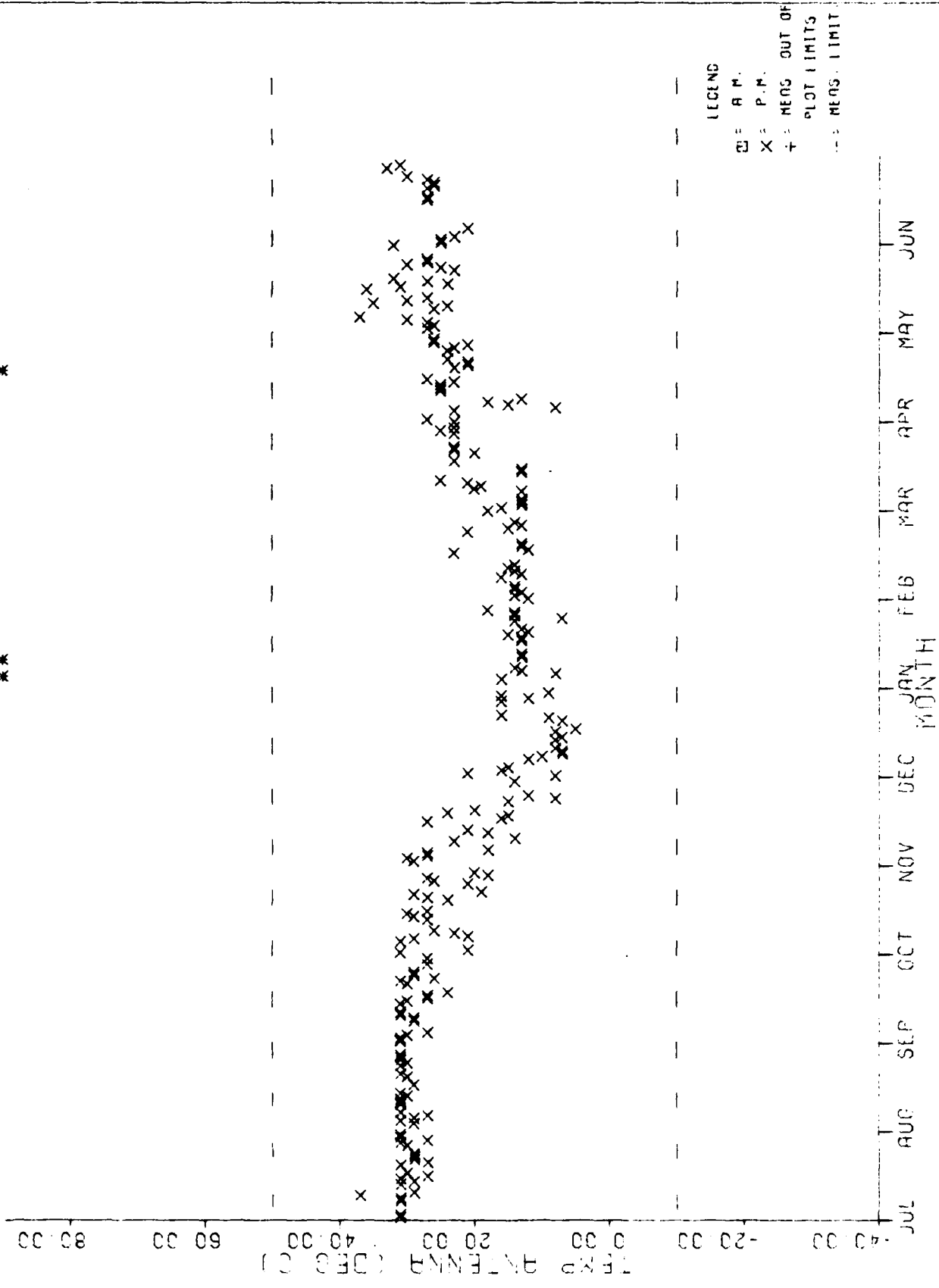


FIGURE D-24. ELEVATION MONITOR, JULY 1981-JUNE 1982, ANTENNA TEMPERATURE
 PARAMETER P.M. PLOT

ELEVATION MONITOR JULY 1982-JUNE 1983, BEAM ACCURACY
 DATA SOURCE: ELEVATION MONITOR, CITY OF PITTSBURGH, PA.

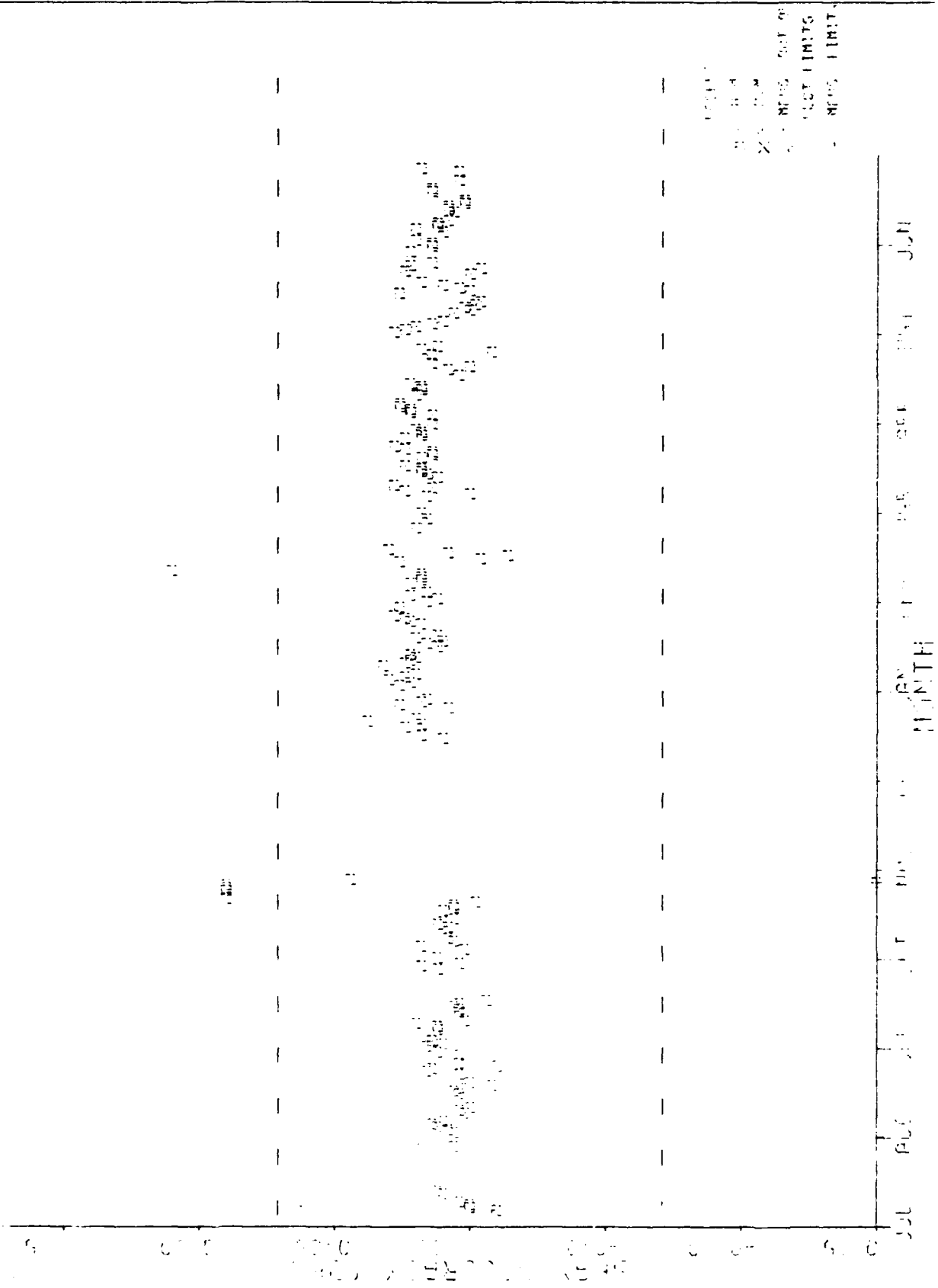


FIGURE D-25. ELEVATION MONITOR, JULY 1982-JUNE 1983, BEAM ACCURACY
 PARAMETER A.M. PLOT

HIGH WATER MINIMUM JULY 1982-JUNE 1983, BEAM ERP
 1000 900 800 700 600 500 400 300 200 100 0
 100 200 300 400 500 600 700 800 900 1000
 1000 900 800 700 600 500 400 300 200 100 0
 100 200 300 400 500 600 700 800 900 1000

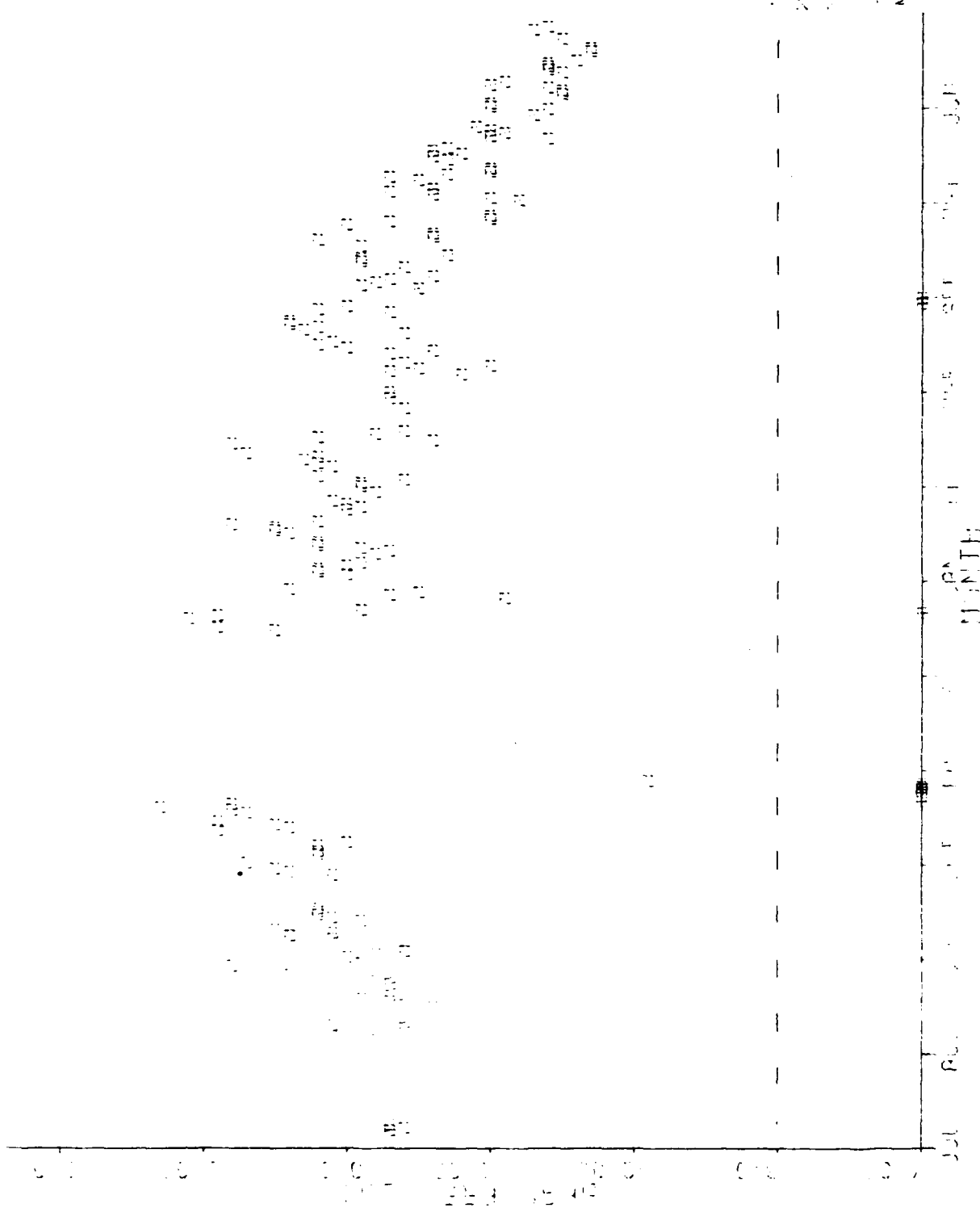


FIGURE D-26. ELEVATION MONITOR, JULY 1982-JUNE 1983, BEAM ERP
 PARAMETER A.M. PLOT

11000
 10000
 9000
 8000
 7000
 6000
 5000
 4000
 3000
 2000
 1000
 0

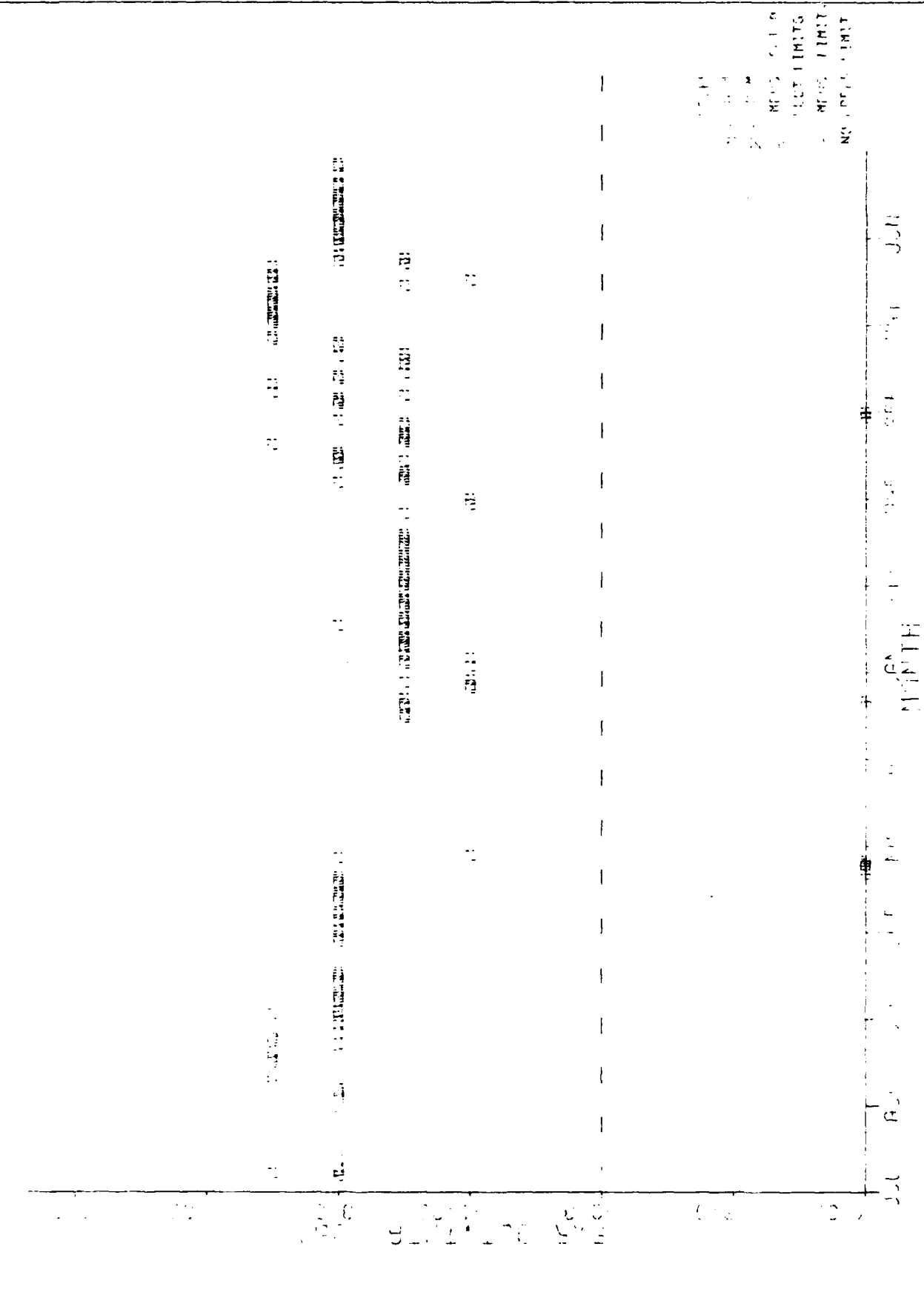


FIGURE D-27. ELEVATION MONITOR, JULY 1982-JUNE 1983, ANTENNA TEMPERATURE
 PARAMETER A.M. PLOT

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 100

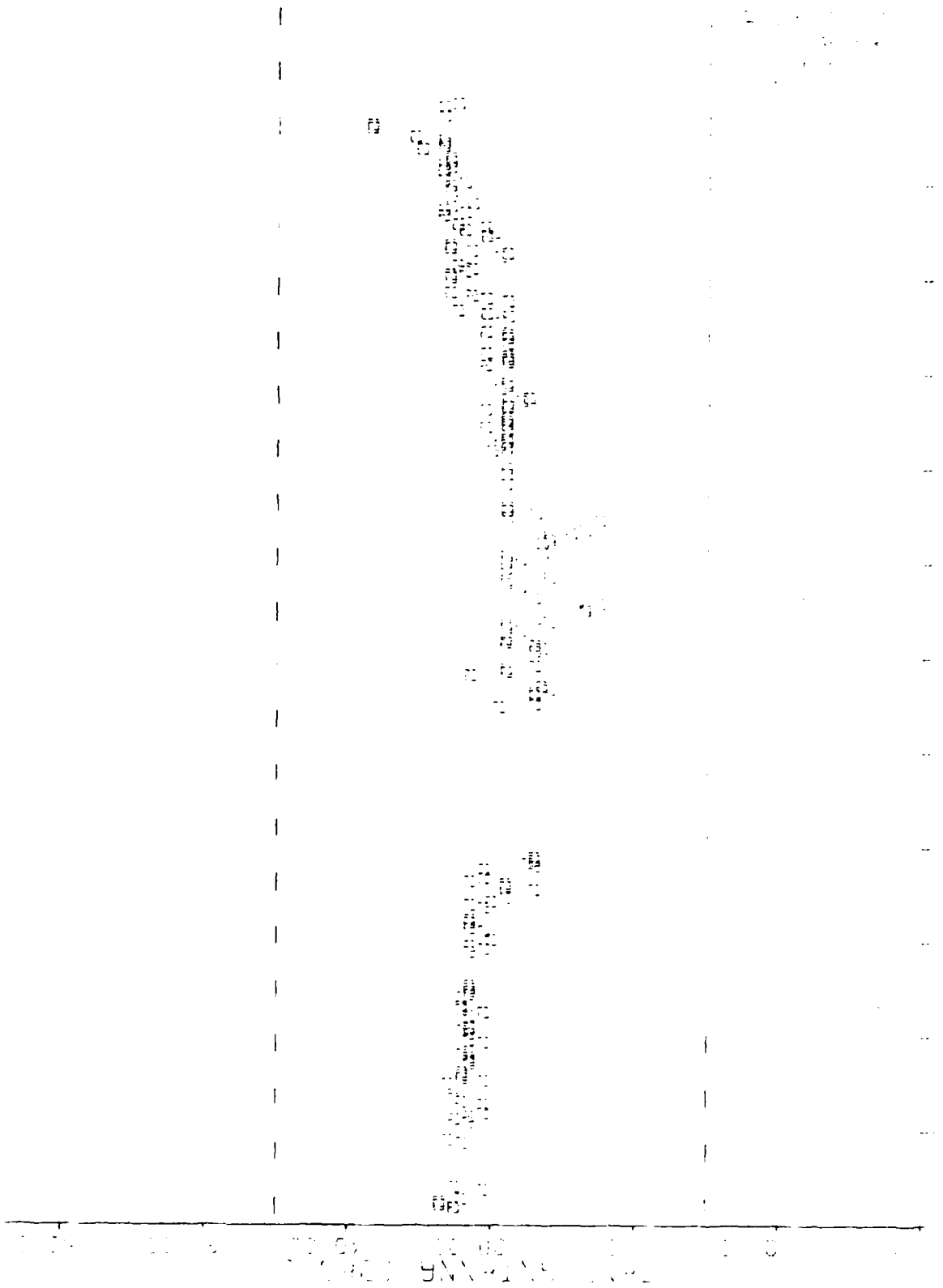


FIGURE D-28. ELEVATION MONITOR, JULY 1982-JUNE 1983, ANTENNA TEMPERATURE
 PARAMETER A.M. PLOT

WASH. MLS EL. MONITOR: JUL., 1982-JUN., 1983, P. MCENTER, ATLANTIC CITY AIRPORT, N.J. 08405

DATA RECORDED AND PROCESSED BY THE FAA TECHNICAL

0.15

0.10

0.05

BEAM ACCURACY (DEG)

-0.05

-0.10

-0.15

-0.20

JUL

AUG

SEP

OCT

NOV

DEC

JAN

FEB

MAR

APR

MAY

JUN

*

LEGEND

□ A.M.

× P.M.

+ MEAS OUT OF

PILOT LIMITS

- MEAS LIMIT

FIGURE 29. ELEVATION MONITOR, JULY 1982-JUNE 1983, BEAM ACCURACY
PARAMETER P.M. PLOT

WASH. BUS EL. MONITOR: JUL., 1982-JUN., 1983, P.M. CENTER, ATLANTIC CITY AIRPORT, N.J. 09405

DATA RECORDED AND PROCESSED BY THE FPM TECHNICAL

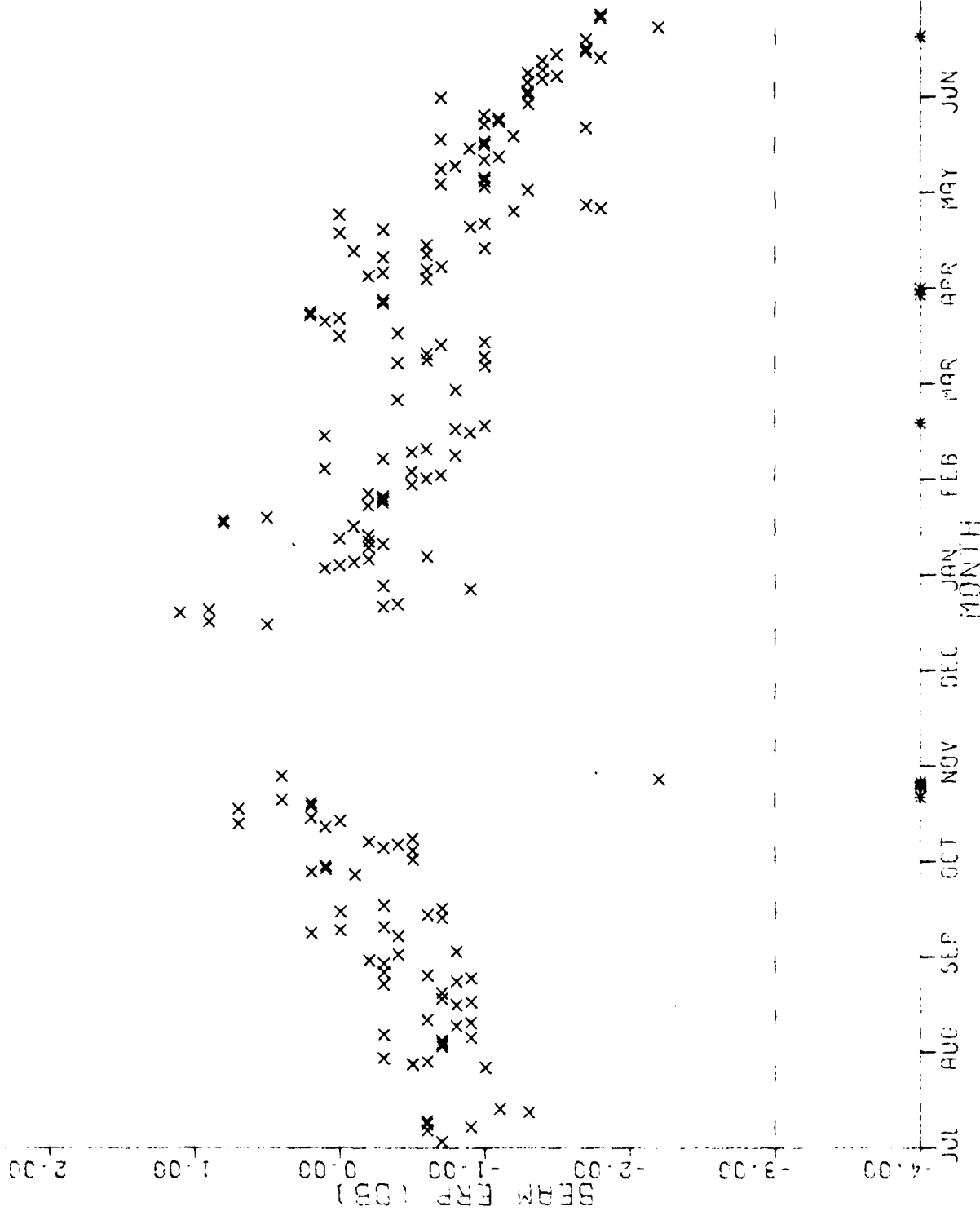


FIGURE 30. ELEVATION MONITOR, JULY 1982-JUNE 1983, BEAM ERP
PARAMETER P.M. PLOT

WASH. MLS EL. MONITOR: JUL., 1982-JUN., 1983, P. MCENTER, ATLANTIC CITY AIRPORT, N.J. 09405

DATA RECORDED AND PROCESSED BY THE FNN TECHNICIAN

2.00

1.00

0.00

-1.00

-2.00

-3.00

-4.00

PWR OUT, TWTA (DB)

JUL

AUG

SEP

OCT

NOV

DEC

JAN

FEB

MAR

APR

MAY

JUN

MONTH

FIGURE D-31. ELEVATION MONITOR, JULY 1982-JUNE 1983, TWTA POWER OUT
PARAMETER P.M. PLOT

LEGEND

□ = A.M.

X = P.M.

+ = MEAS. OUT OF

PLOT LIMITS

-- = MEAS. LIMIT

NO UPPER LIMIT

WASH. MLS EL. MONITOR: JUL., 1982-JUN., 1983. P. M. DATA RECORDED AND PROCESSED BY THE FAN TECHNICAL CENTER, ATLANTIC CITY AIRPORT, N.J. 08405

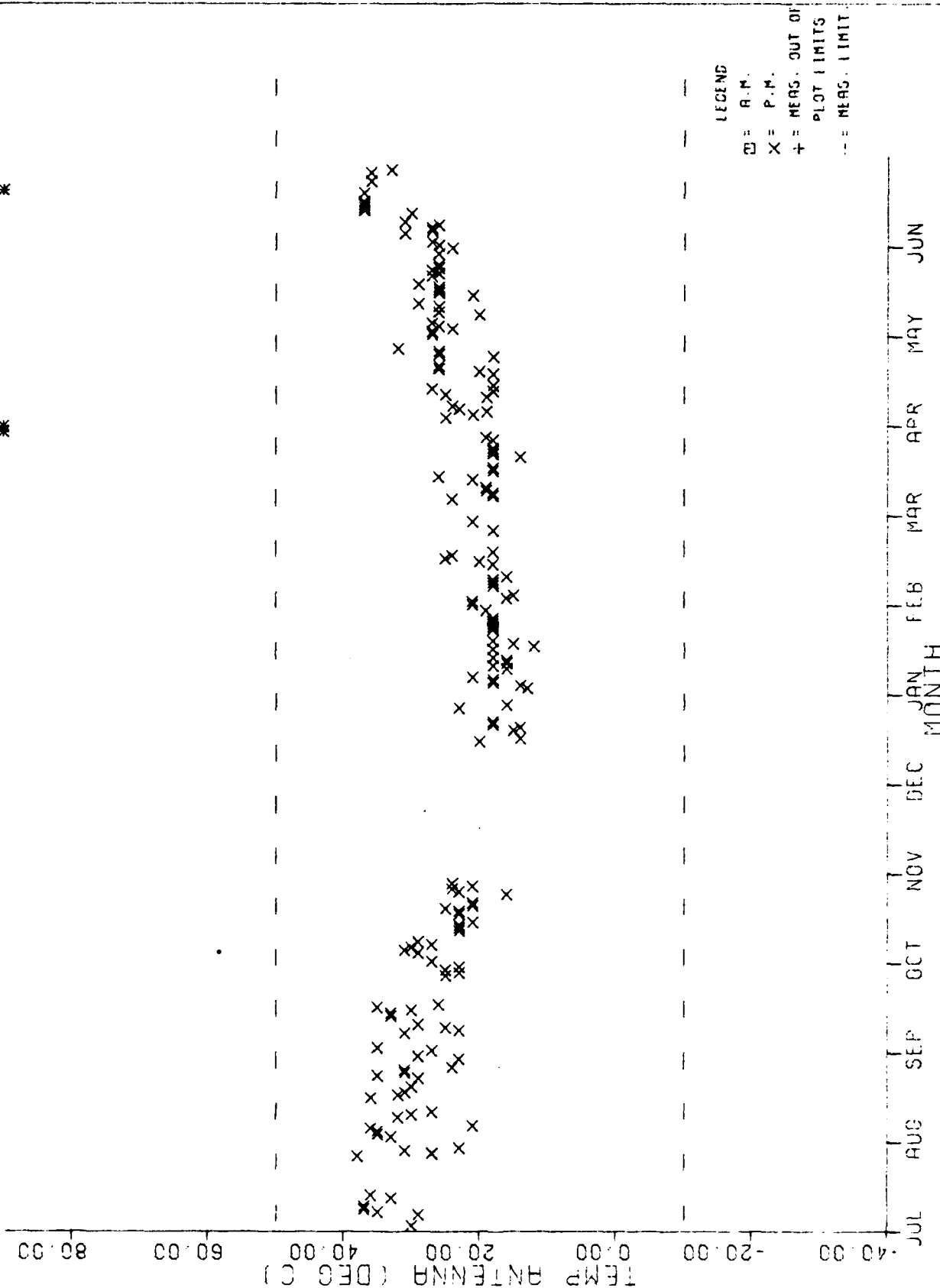


FIGURE D-32. ELEVATION MONITOR, JULY 1982-JUNE 1983, ANTENNA TEMPERATURE PARAMETER P.M. PLOT

END
FILMED

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